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Typographic Legibility for Retinitis Pigmentosa Readers

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Typographic Legibility for Retinitis Pigmentosa Readers

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September 2001

Declaration

I certify that this thesis which I now submit for examination for the award of M. Phil., is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my own work.

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Signature Ann Benedette Date September 2001

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Carla Benedetti

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Abstract

Although numerous papers have been written on the subject of legibility, there appears to be a lack of research into the relationship between printed matter and visual impairment in this context. The research aim of this thesis is to conduct a comprehensive study on the reading performance of those suffering from a particular impairment, namely Retinitis Pigmentosa and to identify typographic considerations that would improve this performance. The work confirms the importance of specially designed material and the need for specific guidelines to ensure optimum legibility for particular eye deficiencies.

This thesis outlines the reasons for researching the legibility of text as presented in print form as distinct from that presented to on-screen users. Various descriptions of previous research are documented and analysed in order to choose the most appropriate method for testing RP subjects. A section of the research is devoted to the ophthalmic aspect of visual impairments with a description of the characteristics and associated symptoms of RP.

The differences between legibility and readability are established which leads to an outline of a number of the design factors that have an important impact on legibility for partially sighted readers and certain characteristics that should be avoided.

The final part of this thesis is concerned with the testing of a group of 20 RP subjects and a control group of 7 subjects. The data analysis and princpal findings highlights the discrepancies between subject choice and subject performance.

In conclusion this thesis outlines the complexities involved in trying to optimise legibility for visually impaired readers with particular eye deficiencies. It is hoped that this research will make a significant contribution to the understanding of the typographic needs that affect the reading ability of RP sighted individuals. The thesis submission consists of two volumes; the written research and the inclusion of a physical design solution, developed from the findings obtained during the evaluations.

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Chapter 1

Introduction

1.1 Research Aims

Over the past century, numerous papers have been written on the topic of legibility and the basis of reading, for people with normal sight. With such extensive reviews readily available, the aim of this study is to evaluate a range of typographic presentations in order to identify optimal configurations for sufferers of Retinitis Pigmentosa (RP).

The objective of the study is to establish important design factors that aid legibility for RP readers, while optimising their remaining visual capacity for reading. By addressing this subject, it is hoped that design recommendations can be defined for designers producing material for RP readers.

A common theme emerges from the author's literature review on the subject of design legibility and visual impairments. While general information regarding legibility is extensive and readily available, there is quite an obvious lack of research on the relationship between printed material and visual loss. Although a great deal of valuable information can be derived from general legibility studies, this is not a sufficient means of identifying the correct design requirements for low vision readers.

There is almost a total absence of information regarding the effects of individual visual disorders upon visual performance and there appears to have been no fundamental research on improving reading conditions for RP sighted readers in Ireland. The overall objective of this research is to carry out tests, analyse the results and to utilise these to develop more appropriate design criteria for RP readers.

1.2 An Outline of the Parameters of the Problem

Mc Donald-Ross and Waller maintain that, 'The purpose of legibility research should be to improve the quality of practical decisions.' [1]

Most of the current research on legibility has been accomplished by psychologists and ophthalmologists whose approach is naturally often very scientific. It is perhaps not surprising that designers may not consider the needs of the sight impaired from the point of view of practical application. Designers are often required to fulfil design briefs based on aesthetic criteria and design trends. Aesthetic trends generally do not cater for low-vision individuals suffering the daily problems of living with a sight impairment. Many of the fashionable features in certain design domains are entirely oriented towards people with perfect vision for example the trend for tightly spaced lettering has the detrimental effect of producing a mass of black print for someone with a visual impairment. Layering of text over photographs which can be seen in many magazines and advertising spheres is almost impossible for a low vision reader to decipher.

1. Foster, J. J., *Legibility Research 1972/1978 - A Summary*, Graphic Information Research Unit, RCA, 1980, p. 9.

However, it is important that current design trends and aesthetic qualities, while theoretically not of significant importance in print material for sight impaired readers, should not be ignored. Aesthetics will have a considerable effect on any individual's desire to read for long periods and it is the challenge of the designer to provide appropriate, well designed, material that fulfils this requirement, while conforming to legibility standards. Visual impairment does not imply visual illiteracy or an unawareness of aesthetic qualities.

In his book 'Methods of Book Design', H. Williamson captures the extent to which aesthetics have influenced the work of normal print.
'The compositor seeks to do more than to protect the reader against inconvenience; he seeks to attract the eye to his pages, arranging intractable material with elegance and apparent ease.' [2]

Johnston et al. 1976, discuss the need for designing visual displays for the 'real' observer. By this they mean that the requirement of the designer is to convey information that can be transmitted to people with less than perfect vision and yet remain close to the aesthetic design approach, used for those with 'normal vision'. They observe that information is lacking concerning both the incidence of visual disorders and the effects of visual disorders upon visual performance. [3]

2. Williamson, Hugh., *Methods of Book Design*, Yale University Press, 1983, p. 53.

3. Foster, op. cit., p. 9.

The interaction with text and the abilities of the sight impaired reader, although different, are no less important than for sighted persons and often the criteria that define legibility apply equally well to the partially sighted reader. Although design layouts should, ideally be tailored to the requirements of particular deficiencies, in the earlier stages of diagnosis, these may differ only slightly from those of normally sighted individuals. Hence, literature on the legibility of print for general readers remains very relevant.

1.3 The Importance of Specially Designed Reading Matter

A number of factors emerge from the literature review as the principal variables that affect legibility and low vision. It is recommended that 16 point is the minimum type size to aid low vision readers and that semi-bold and bold typefaces should be used to give maximum legibility. Italic type reduces legibility and therefore should be avoided; opaque, matt paper with no 'see-through' provides the optimum print surface. [4]

Contrary to these recommendations, enlarging type is not always an appropriate factor as the extent to which letters should be enlarged should depend on the distance they are viewed at, the readers field of vision and on the nature and extent of the particular sight impairment. [5] In the case of RP the degree of peripheral loss acts as a limiting factor on utilisable font sizes.

4. The guidelines above are adapted from J. Gill, *Access Prohibited? Information for Designers of Public Access Terminals*, RNIB publications, p. 22. 'No-see through' refers to the use of good quality paper which is thick enough for text on the reverse side not to show through. Paper with insufficient thickness or opacity will have a detrimental effect on reading performance.

5. Alison Shaw, *Print For Partial Sight*, p. 64.

Previous tests results promulgated by Alison Shaw, conclude that type size is an important factor for sight impaired readers but excessive enlargement may hinder legibility. [6]

The view that enlarged, dense, type is appropriate for all sight impairment conditions is a questionable generalisation and provides an inadequate and insufficient basis for addressing the legibility requirements of specific impairment groups. The legibility requirements of these groups is classified by the exact nature and extent of eye defect. Such diversity necessitates the formulation of 'defect specific design guidelines' to ensure optimum legibility.

Advancements in the fields of research and treatment are enabling ophthalmologists to improve conditions for the sight impaired and to create an awareness of the distinct differences in perceiving information. There are many major causes of sight impairment which serve to illustrate the complexity and diversity of particular conditions. A shared visual impairment may be the only common descriptive attribute relating to sight impaired readers; readers with cataracts are not helped as much by increasing type size as they would if the weight of the letters were increased; myopic readers however value the increase in size but are not particularly helped by changes in weight. (Refer appendix A2 and A3 for a summary of visual impairments).

6. See Appendix B for the effect of type enlargement on RP.

The main subject matter of this thesis is concerned with the typographic legibility for a progressive degenerative sight impairment, namely Retinitis Pigmentosa, (RP). It is estimated that there are in excess of 1,000 people suffering from varying stages of the disease Retinitis Pigmentosa in Ireland and a total of 65,000 people nationwide, who suffer from retinal degenerative diseases. With such a significant percentage of the adult population in Ireland with low vision, there is clearly a need for research on the relationship between design requirements and particular eye defects. [7] Until recently RP was regarded as a rare disease, but since attention was focused on it by the formation of RP societies worldwide, it has been acknowledged as being one of the most common forms of blindness.

The specific effect of a visual impairment on reading depends on the nature and severity of the visual problem, and on the particular stage of reading development at which the anomalies occur. Generally R.P. takes effect between adolescence and adulthood, although in rare occasions, symptoms may appear either in earlier or in later life.

Within a wide range of visual deficiencies there are also many individual requirements for reading not related specifically to sight. The personal attributes of the reader; will power, incentive and interest in reading play as important a role as the physical amount of vision in determining whether a partially-sighted person actually does much reading.

7. In Ireland, an active society was formed in February 1983, namely RP Ireland-Fighting Blindness who are part of a worldwide movement to combat Retinitis Pigmentosa. Significant research is currently being pursued in Ireland to find therapies in the field of medical and scientific research, and there is a lot of attention being focused on finding treatments for RP conditions. The above statistics are derived from a personal interview with Michael Griffith, Director of RP- Ireland Fighting Blindness. I wish to acknowledge his assistance and the help of his associates for providing me with essential research material and for their kind support when locating RP subjects.

Retinitis Pigmentosa is typically characterised by the retention of central vision and a progressive deterioration in peripheral vision over a certain period of time. 'One of the most interesting aspects of the natural history of RP is the relative preservation of central vision in most patients for prolonged periods, even though there is progressive peripheral vision field loss.' [8]

The importance of legibility does vary with typographic changes according to the nature and severity of partial sight. The preservation of central vision in RP, which in certain cases may be prolonged well into old age, provides the potential for the designer to make significant alterations to design layout for improving the transmission of information. It was for this reason that RP was chosen as opposed to other sight deficiencies, as the subject of this research.

Despite this, it is very difficult to devise an ultimate resolution governing print standards, or to produce hard and fast rules that will be applicable to every design problem that arises. It is possible however, in a study such as this, to produce a basis for practical decision making and to highlight the inadequacy of current measures employed for the transmission of information, not solely to RP readers, but to sight impaired readers in general.

8. Heckenlively, J. R., *Retinitis Pigmentosa*, J. B. Lipencott Company, Philadelphia, 1988, p. 77.

Chapter 2

Print Legibility Versus On-Screen Legibility

2.1 The Choice of Print Legibility over legibility for Screen

David Smith, in the Sunday Times argues that recent advances in the digital media may make reading from print obsolete;

> Today the death of that lowest of low-tech gadgets, the book and the consequent demise of libraries, is predicted with equal solemnity. Do you read fiction? Then once again the jostling scum of competing screen-based media is cited as the grim reaper. Do your tastes run to manuals and reference books? Then the welter of on-line and disk-based information available from your computer will expunge that market also. [1]

Despite the many advantages of on-screen electronic publishing, for example the potential size of its audience, its lower production and minimal distribution costs, and through network and computer technology, the electronic revolution does not save society from the waste of bundles of printouts. If the computer is over-riding the age-old method of print, why are people buying an increasing number of books yet still printing hard copies of text to read what appears in front of them on their computer screen? One could answer that reading large amounts of text from a computer monitor is a slow process and likely to cause eye-strain and irritability.

1. Smith, D., *'Sweet and Low,'* The Sunday Times, 31 May 1998.
By the UK government's own trade figures, all kinds of book sales have increased by 0.2 billion, in one year, from 1996 to 1997. According to the market research company 'Book Market Ltd,' this suggests more than mere cover-price rises. More books are being sold at a time when there is a massive increase in computer ownership and internet access.

Legibility tests on documents from computer screens prove that 'almost universally, and completely language independent, reading speed falls between 10 and 25%'. This is because, 'The writers of early software were aware that the users would desire to print out the document being viewed, everything was focused towards the final result, i.e. the printed page. The screens were considered to be temporary pages conceptually.' [2]

Developments in typeface design, computer typesetting and printing have produced remarkable improvements in quality. In contrast, the current limitations inherent in reading from low-resolution monitors of various sizes means that the digital designer has to be very careful about choosing typefaces that are easily read on-screen. Typefaces in the future will need to be legible at a type size of 10 point or smaller which may not suit the sight impaired reader.

As we are expected to read on-screen documents more readily, more and more pages will be designed for the size and proportions of a computer screen, thus large type sizes will be unsuitable for the confined space of the screen. With this electronic format as the standard, there is the added pressure to keep type sizes small which has major consequences on the effects of legibility.

2. High. C. R., 'The Art of Design for Legibility' for Tenex Software Engineering of Olympia, Washington, USA, 1995-1997, Http//www.halcyon.com/chigh/artlegw.html

It is doubtful that web designers will use large font sizes for lengthy documents of text. Until recently, options for improving on-screen legibility have been limited. New approaches to technology are aimed at overcoming this problem but their success is disputed. James Felici, author of 'The Desktop Style Guide' comments,

> I've heard explanations of how greyscale fonts can create more legible screen-type at small point sizes by using grey scale pixels as well as black and white ones to create an impression of smoother character shapes. But from what I've heard from the medical community, greyscale fonts are murder on the eyes. One of the things that makes all computer screen reading so tiring is that the images of type on screen are not crisp enough, they are a little blurry around the edges. Our eyeballs in the face of this fuzziness are battling full time in a futile effort to draw a sharp focus. All these non-stop micro-adjustments of your eyes' focal length are cumulatively fatiguing and eventually you go bleary eyed. [3]

Greyscale fonts certainly may be the way of the future for improving on-screen typography, but by eliminating the jaggedness associated with high contrast fonts, they increase the problem of ill-defined, soft edges with text type, which causes eye-strain.

Robin Nicholas suggests that the computer user has now more than ever, a diminishing concentration span on slow downloading of web pages. Both those with normal vision and the partially sighted are much less perplexed when reading printed matter than incurring the frustration of searching for information on badly designed web pages. [4]

3. This reference is from a typofile discussion by Felici. J., 'The Desktop Style Guide', (Bantam/ITC), Http//0005646865@mcimail.com
4. Robin Nicholas, Head of Typography at Monotype, made the above observation at a Monotype seminar held in Dublin in the Spring of 1998.

The relationship between on-screen design, and its effect on legibility remains an unresolved issue. For several hundred years printing has provided an efficient and effective means of communication. Typesetters who once worked with metal type had control over many of the factors that affected the legibility of printed matter. The control of costs and time of reproduction which were placed on text forced certain limitations on experimentation of presentation. To some extent, limiting the choices of typeface encouraged legibility in the final product. Since digital publications became standard, a significant amount of control has passed to various software programmers and users, many of whom have no training in graphic design and make poor choices that ignore or hinder legibility.

Today we can choose the best of new technology for effective presentations and efficient transmission of knowledge but that does not necessarily mean we should reject the paper book. Until recent advancements in computing capabilities and a sophisticated multimedia network, printing was our greatest knowledge resource and it still remains an important method of distributing information. [5] Such prolific improvements in technology should be used to advance the reproduction of text for sight impaired readers.

5. Van Blockland, E., and J. Van Rossum, in 'Is Best Really Better' *Emigre* 18, state that 'Compared to printing techniques as they existed, in the early 15th century, we have indeed come along way. We can digitally output the most perfectly drawn typefaces directly onto film in resolutions of up to 5,000 lines per inch. We can print in offset, in perfect registration, on the smoothest papers and finish it off with layers of varnish, all at a speed that our 15th century forefathers would find baffling. Technically, we can produce the slickest printing ever, reaching the highest possible quality ever.'

For many purposes, the printed book has advantages over reading from screen. The impact of poorly designed on-screen material is significantly multiplied for someone with a vision deficiency. Legibility research based on particular sight impairments is relatively new, and it may be helpful to identify optimum factors for print before progressing to legibility for screen.

Furthermore, we must also recognise that, until recently, sight impaired people were victims of a system that did not encourage a progression to higher education after second level, and did not support the development of skills to fulfil individual potential. The practical application of computers did not extend throughout the education of many middle-aged people who have developed RP in their late teens. Consequently these people are reluctant to use computers and would rather continue to read print. It is consequential to these aspects, that this study concentrates on the research of print matter over on-screen legibility.

Chapter 3

Methods of Investigating Legibility

3.1 Techniques used in Investigating Legibility.

There is widespread lack of agreement among researchers about what constitutes a valid method of measuring legibility. Two particular criticisms of legibility research are, firstly, the reliance upon the inappropriate single-variable experiment, where results are only relevant to the conditions they are tested under and secondly, the tendency not to compare testing material to attainable alternative designs of 'real-life' material.

There is also the need to exclude methodological faults and experimental bias from research. The lack of reliable performance can be an outcome of various inconsistencies; treatments should be standardised throughout the testing process, subjects should always be given the same material, and the expectations of the subject and their general motivation should be taken into consideration. Furthermore, one cannot assume a correlation between reader's preference and the speed and ease of performance. Reading speed can be influenced by the type of test a reader anticipates and the competence of the literary skills of the reader.

There are two general methods of testing legibility; rate measures and threshold techniques.

A. Rate Measures

Rate measures are used for measuring rate of work, blink rate, speed and accuracy of performance. These methods are applied when testing continuous text for ease and fluency of reading. The differences in the legibility of the texts are reflected in the testing results. [1]

B. Threshold Techniques

Threshold techniques measure the accuracy with which letters or words are perceived, when they are seen, for a limited period of time or at a given distance. By measuring differences in the exposure times at which various print combinations are perceived, it is possible to establish which is more legible. Similarly, by measuring the distances at which letters are correctly identified, the legibility can thus be determined. Results from this method of testing are particularly useful for redesigning typefaces and for making improvements to existing print styles. It is a much less appropriate method for studying such factors as optimum type size and line length because only single items are presented at any one time.

1 The significance of the reliability of the four main groups of testing measures is discussed by Hartley et al, 'Some Observations on the Reliability of Measures used in Reading and Typographic Research', *Journal of Reading Behaviour*, VII,3, No 3, 1975 pp. 283-296, and are referred to in Appendix C1.

3.2 Speed of Perception

A tachtiscope is an instrument used to reveal the accuracy of recognising printed matter through tests involving short term exposure. It determines the relative legibility of different letters or alternative forms of the one particular letter. The length of exposures last for an average of 1/10 of a second, and legibility is measured by the time taken to perceive the stimulus. Experts use this technique to examine the various factors that affect the legibility of a printed symbol such as the presence of serifs, thickness of stroke, letter under lining, use of italics etc. A tachtiscope is not a valid means of testing typographical layouts of prose passages as it determines the legibility of single letters only. [2]

3.3 Distance Test

The distance test is used to determine the furthest distance from the eye at which individual letters can be accurately perceived as a measure of its legibility. It can be misleading when it is used to measure the legibility of texts designed to be read under normal reading conditions i.e. at a distance of 12-14 inches from observer to text. [3]

2. Spencer, H., *The Visible Word*, p. 22.

3. Legibility; Techniques of Investigation, Http://152.1.69.5/-covington/legibinl.html p. 1.

3.4 Perceptibility of Peripheral Vision

This test determines the horizontal distance from a fixation point of the eye at which a letter can be accurately perceived. [4] Eye movement measurements are highly reliable methods for measuring the legibility of print and valid indicators of reading performance. A substantial difference in the number of fixations relates to many factors, including text difficulty, print size, spacing and experience of the reader.

3.5 Visibility

This technique for determining the legibility of test materials is usually measured by the Luckiesh-Moss Visibility Meter, which determines the threshold of visibility of printed letters and words. This test measures the variations in brightness and contrast between text and paper. The meter consists of two filters which, when rotated, vary the contrast until the letters or word is identified correctly. It is not suitable for measuring prose text. [5]

3.6 Reflex Blink Technique

The reflex blink technique is a study of the physical behaviour of the eye while reading. It consists of counting the number of blinks a person makes while reading, based on the assumption that reading print with less than optimal legibility will increase the readers frequency of blinking. [6] The validity of this test is questionable and unreliable and yet there is revisionist views regarding the use of this test. It would be unorthodox to use this procedure with sight impaired readers, as the blink rate of the abnormal eye is likely to be erratic and unreliable.

4. op. cit., p. 22.

5. Garzia, R. P., *Vision and Reading*, p. 89.

6. Tinker, M. A., *Legibility Of Print*, p.6

3.7 Analysis of Eye Movements

Eye movement analysis is widely used to measure how much an individual can read in a set amount of time, ranging from direct observation to more precise and reliable methods of mechanical or electrical control. The advantage in analysing a readers eye movements is that the movements provide information as to why a non-optimal typographic arrangement is read more slowly than optimal arrangement, since eye movements indicate how the subjects visual search strategy is affected. This is not a suitable test procedure for use with the abnormal eye, as this method depends on physiological and muscular functions. [7]

3.8 Fatigue in Reading

Research into fatigue in reading is largely based on on the belief that visual fatigue is a direct result of inefficient and illegible type. Carmichael and Dearburn (1948), undertook an extensive study of fatigue in reading . Their results showed no significant changes occurred in subjects even after prolonged exposure to reading. [8] Tinker also investigated the relationship and found the validity of this method questionable. His reasoning for this is the amazing flexibility and adaptability of the human visual mechanism in its capacity to adjust to a bewildering variety of situations requiring visual discrimination. [9]

7. Legibility: Techniques of Investigation, op. cit., p. 1.

8. Carmichael, L., and Dearborn, W. F., *Reading and Visual Fatigue*, Boston: Houghton Mifflin Co. 1947., pp. .206-451

9. Tinker, M.A., *Legibility Of Print*, p.20

3.9 Rate of Work

Rate of Work determines the legibility of printed texts and has been used widely by researchers Pyke, R. K., Paterson, D. G., Tinker, M. A., Ovink G. W., and Burtt H. F. [10] Providing the text is fully comprehensible, performance output is the dependent variable, because the subject is mentally engaged in the activity. Rate of work is ideal for determining the legibility of continuous text and it can also be considered a measure of comprehension by taking into account the number of errors made by a subject. The technique can be applied either;

- By measuring the amount of reading completed in a predetermined amount of time or alternatively by recording the amount of time taken to read a text.

- By imposing a work limit and timing how long it takes to find something, for example, a phone number in a phone book, a word in a dictionary or a timetable.

- By measuring the amount of work output in various situations involving 'visual discrimination'.

10. Tinker. M., A. *Legibility Of Print*, p. 7.

3.10 Speed of Reading

Speed of Reading performance in continuous text has been adopted by most researchers as a criterion of legibility. Use of the Chapman-Cook Speed of Reading Test permitted measurement of speed reading as a single variable. It consists of 30 short paragraphs of 30 words each. Each paragraph contains one word that is contextually inappropriate. The reader's task is to read the various paragraphs and to cross out the inappropriate words. The following is an example of one such test;

> When I am enjoying anything very much, time seems to go very quickly. I noticed this the other day, I spent the whole evening reading a very ~~uninteresting~~ book. [11]

The incongruous word is uninteresting. The number of paragraphs completed within a a specified time is the measure of reading rate. The typical testing time is 1.75 minutes. Later a similar method of testing was formulated by Tinker, who allowed an extended time of 30 minutes for testing. Tinker's Speed of Reading test consisted of 450 items of 30 words each. [12]

Although this testing method was once considered a purer method than any of the previous tests, it is hardly a measure of legibility and of any affect the print may have in producing better comprehension goes unnoticed.

11. Garzia, *op. cit.*, p. 3.

12. Tinker. M., *A. Legibility Of Print*, p. 21.

3.11 Scanning Method

The scanning technique was devised by Poulton in 1967 who claimed it to be a reliable and sensitive measuring device. This test consists of skimming prose for specified target words or phrases. Smith and Goodwin, 1972 used an error-detection task in which subjects had to find letter substitution errors in 12-line texts. They maintain that such check-reading may provide a more sensitive measure of display legibility than other techniques. Spencer, Reynolds and Coe, 1977 used a scanning task in their study of the different kinds and intensities of background noise on the legibility of printed text and numerals. Subjects searched sections of texts for target words listed adjacent to the appropriate section. The scanning method of testing is said to be particularly appropriate for measuring the way in which scientific and technical reading material is often read. [13]

3.12 Readers Opinions

The perceived aesthetics of an individual typeface has a poor correlation with measured reading rate. [14] Personal preferences and readers' opinions are an ineffective means of obtaining theoretically sound results, and judgements are not always consistent with objective measures of reading performance and ease of use. However, opinions and personal comments do provide information that may not be so evident from statistical results and therefore provide valid indications from this perspective.

13. A more detailed description of the scanning method of testing is outlined in Part 7.7

14. Information on techniques of investigation were adapted from, Garzia, R. P., *Vision and Reading*, p. 91.

Tinker conducted tests in 1963 to study the relationship between judgements of pleasingness and judgements of legibility for a number of typographic variables. His conclusions were that, 'Readers place high aesthetic values on those printing arrangements that appear to be most legible. [15]

15. Tinker. M., A. *Legibility Of Print*, p. 50.

Chapter 4

Previous Research Work

4.1 Earlier Research Work on Legibility

A considerable amount of research has been accomplished during this century into the legibility of print and also into the psychological and physiological process of reading. Corresponding research on legibility and its relevance to sight impairment tends to conform to the notion that all visual impairments should adhere to the same print guidelines, and little is known about the impact of legibility on particular sight deficiencies. Few studies on current legibility measures and their effects on low vision have been conducted by designers and are mainly accomplished by researchers or experts in the field of optics and ophthalmology. As a first step towards selecting the factors to be investigated in the present study, previous research with particular relevance in the field was analysed with some specific findings summarised below.

4.2 Prince, J, H. 1967

Prince was one of the main contributors to early research on legibility for the partially sighted adult. While earlier investigations approached the problem mainly from a teacher's perspective, Prince was one of the first opticians to conduct research studies on legibility. His work was largely concerned with developing a specific type style for sight impaired readers. He found that differences in legibility between various styles of type diminish as the size of the type increases. [1]

1. Spencer, *The Visible Word*, p. 27.

Prince also reported on the difficulty experienced by sight impaired readers in distinguishing between the comma and the full stop, and recommended that the full stop should be 30% and the comma 50% of the height of the lower case o. [2] He recommended the use of hyphenation to improve legibility for sight impaired readers and came to the conclusion that when strong behaviour patterns have been established before the onset of visual deterioration, traditional fonts although not necessarily clearly observed, are read more easily than specially designed ones.

4.3 Poulton, E, C. 1968

Poulton compiled a test which combines rate of reading and degree of comprehension into a single test. The reader is given a passage to study for a limited time, and then has to answer questions based on what he read. The score from the questions depends partly upon how much of the passage he was able to read in the time and partly upon how well he comprehended what he had read. Poulton was one of the first researchers to use the scanning method as a means of testing legibility, by measuring the legibility of the names and doses of medicine on the labels of containers. He later used the same method for measuring the conspicuousness of newspaper headlines and the ease at which columns of news can be scanned, with a group of housewives. His results showed, 'A difference as large as 7% for a change of only one point in the size of the letters, and the findings of reliability with as few as 50 housewives, suggests that this method of speed of scanning may be more sensitive to small changes in size of type, than the speed of reading method pioneered by Tinker and Paterson.' [3]

2. *op. cit.*, pp. 34-35.

3. Poulton E.C., 'Skimming (Scanning) News Items Printed in 8-Point and 9-Point Letters', *Ergonomics*, vol. 10, No. 6, p. 715.

4.4 Spencer, H. 1969

The Visible Word is perhaps one of the most detailed accounts on the study of legibility in recent decades. The research is an amalgamation of test results, reviews, summaries and conclusions. It is not confined to conventional studies but also reports on aspects of technology that deal with the reported effects of legibility studies. Spencer investigates the legibility of print, in a language and form acceptable to designers. While the author's research is thoroughly documented, the implications regarding design presentation for sight impaired readers, are limited as it concentrates on legibility for 'sighted' individuals. [4]

4.5 Shaw, A. 1969

Alison Shaw's research was directly concerned with legibility and print for partial sight for the 'Library Association Research Project' in 1969. [5] Shaw investigated the objective legibility of type face, type weight, type size and type spacing, with a total of 288 subjects. Her findings suggest that optimum legibility is achieved if text is set in a sanserif font, namely Gill Sans. Size appeared to be the most important typographic factor investigated, providing enlargement was not beyond the size necessary to be seen. Type weight, secondary to size, improved legibility for most partially sighted readers when increased from regular to a bolder version. The final variant, type spacing, did not appear to affect legibility and only made a marginal difference to avid readers who found closer spacing more legible and easier to read.

4. Spencer, H., *The Visible Word*, Lund Humphries, 1969.

5. Shaw, A., *Print for Partial Sight*, p. 64. For further results of early research, Shaw analyses studies from pre-1966 on p. 15. of *Print for Partial Sight*.

4.6 Zachrisson, B. & Smedshammar, H. 1971

In 1971 Bror Zachrisson & Hans Smedshammar conducted a foretest regarding certain typographic factors in relation to legibility and partial sight. The aim of this test was to study the effects of print legibility on typographic variables, for partially sighted readers. Among the variables tested were typeface, type size, type weight, inclination and colour combinations. The testing group was a small number of visually impaired readers and a group of normal sighted individuals whose vision was reduced by the use of filter equipped glasses. Subjects read between two and four meaningless texts and the method of investigating legibility was by rate of work and calculating the time taken to read each passage.

No noteworthy results were produced by the group of partially sighted readers. Normal sighted readers whose vision was artificially reduced showed a preference for serifed typefaces over sanserif fonts. Larger font sizes were read better than smaller sizes. Furthermore white letters on a black background significantly reduced legibility for the normal sighted. Yellow text on a black printed background was a vast improvement on black text on a yellow background. [6]

6. Zachrisson B., and H. Smedshammar, *Foretest Regarding Certain Typographic Factors in Relation to Legibility and Partially Sight* - A translation from Swedish, Stockholm; Larahogskolan i Stockholm, Pedagogiska Institutionen, 1971.

4.7 Krisher et al. 1983

Krisher et al. conducted a study which investigated reading speed with a group of visually impaired students and a control group of normal sighted students. Cataract deteriorated retinas vision was simulated with the control group. The visually impaired group was subdivided into those with a normal visual field and those whose sight had defects in the central field. Similar results were obtained from the visually impaired readers and for the simulated visual impairments in normal sight. Krischer et al. concluded that reading speed depended mainly on visual acuity and also on the quality of the retina. [7]

4.8 Babola 1961, Mehr et al. 1973, & Ehrlich, 1987

Babola, Mehr and Ehrlich each conducted studies which prove that the majority of people using both hard copies and closed circuit tv reading machines prefer light figures on a dark background. [8] Babola's work was mainly concerned with viewing single characters and not with continuous prose. [9]

7. Mason H. L., *Spotlight on Special Education Needs Visual Impairments*, Nasen Enterprises Ltd, 1995.

8. Gill, J., J. H. Silver and J. SW. Wolffsohn, *Text Display Preferences on Self-Service Terminals By Visually Disabled People, R.N.I.B. Challenging Blindness.* Http//www.rnib.org.uk/wedo/research/sru/atm.htm

9. Babola, J., 'The Facilitation of Reading by Partially Sighted Persons', *British Journal of Physiological Optics*, vol 18, pp. 220-234.

4.9 Mansfield et al. 1996

Mansfield et al. measured the effect of font with sight impaired and normal sighted readers. Data was collected from fifty normal sighted subjects and fifty two subjects with low vision. Their findings indicate that if print size is smaller than the critical point size, the choice of font could make a functionally significant difference in reading speed and accuracy. The data proved that the maximum reading speed for sight impaired readers is 10% faster with Courier than with Times, although at a similar x-height, Courier is 40% wider than Times. [10]

4.10 Roelofs, T. 1997

Ton Roelofs determined and modelled the effects of eye diseases on visual acuity. He was concerned with the question of how images can be presented optimally to visually impaired observers, based on his knowledge of specific eye disorders. His principal objectives were to find guidelines for the processing of text images and natural scenes, so that the input for the reading and recognition process is optimised or at the least enhanced. [11]

10. Mansfield J. S, G. E. Legge, and M. C. Bane, 'Psychophysics of Reading XV: Font Effects in Normal and Low Vision', *Investigative Ophthalmology & Visual Science,* vol. 37, No. 8, July 1996.
Fonts that run wide require a larger number of pages than condensed fonts for printing.

11. Roelofs, Ton., *Image Enhancement for Low Vision*, Printpartners Ipskamp, Enschede, 1997.

Chapter 5

Retinitis Pigmentosa

5.1 Visual Impairment: A Definition.

Visual impairment, which implies an inability to utilise some aspects of visual perception, is the most common form of disability in the world today.

The term 'visual impairment' extends through a wide range of disorders and an ever changing group of people. In 1992 the World Health Organisation (WHO) defined someone with low vision as;

'A person who despite medical and surgical management has between perception of light 6/18 or a field of vision of less than 10% but is able to use vision for the planning or execution of a task.' [1]

A more functional definition of low vision is, 'The inability to read newsprint at a normal reading distance of 40 cms with standard refractive correction.' [2]

A moderately impaired person cannot recognise a person from across the room (but can recognise them at arms' length) and reports some trouble seeing, even with glasses on. [3] The Lighthouse Research Institute defined severe impairment as, 'The inability to recognise someone at arms length even when wearing glasses, and reports of poor or very poor vision and being blind in one or both eyes.' [4]

1. Gill, J., Silver, J. H., and J. SW. Wolffsohn, *Text Display Preferences on Self-Service Terminals By Visually Disabled People,* RNIB Challenging Blindness. Http://www.rnib.org.uk/wedo/research/sru/atm.htm

2. J. Stephen Mansfield, 'Psychophysics of Reading, XV: Font Effects in Normal and Low Vision', *Investigative Ophthalmology & Visual Science,* p. 1493.

3. Defined by the Lighthouse Research Institute, New York, On-line Reference, Http//www.lighthouse.org

4. *ibid.* Ref. Appendix A for a summary of common sight impairments.

5.2 A Medical Description of Retinitis Pigmentosa

RP is the name given to a group of hereditary diseases in which there is progressive degeneration of the photoreceptors and retinal pigment epithelium. The retina is a light sensitive tissue that records the first stages of seeing. It is situated at the back of the eye and it is this delicate layer of cells that is affected by RP. The retina consists of two types of photoreceptor cells; rod cells and cone cells. There are about six million cone cells in total and they lie in the central portion of the retina. They are responsible for colour vision and for the execution of clear, sharp, detailed work in good light conditions.

Covering the outer edges of the retina, there are an average of 120 million rod cells. The rods are straight, thin cells which are extremely light sensitive. Their function is to pick up peripheral movement outside the main line of vision and they also enable us to see in poor light. Any damage to the rods will affect a person's ability to see peripheral objects.

It is not known exactly what causes RP. The most common feature is a gradual deterioration of the light sensitive cells and the fundus at the back of the eye becomes dotted with clumps of pigment. The problem is due to a breakdown in the function of the rod cells in the retina and eventually, as the disease progresses, the cone cells become affected. [5]

5. Information was adapted from a paper by Catriona Nic Giolla Eoghain entitled *'Visual Defects that Affect the Retina'*, St Mary's School for the Visually Impaired, Merrion Road, Dublin 4.

The onset of RP normally occurs between the ages of 10 and 30. However in rare instances some types of RP may show symptoms only in later life. The most common first symptom is difficulty seeing in poor light or outdoors at night, so called night-blindness. A second symptom is a reduction of the visual field, in which sight is lost from the outer fringes of the field of vision. [6]

The resulting deficiency is commonly referred to as tunnel vision and it is an indicator that the rod cells are affected first. The central portion of the eye around the fovea remains intact and the vision in this central area can continue to be quite good for many years, with visual acuity remaining normal. In due course, the cone cells may destabilise causing gradual loss of central vision and eventually leading to total blindness.

Many retinal degenerations affect the cones, giving colour vision abnormalities. The most common colour vision abnormality seen in RP is a tritanomalous change (blue-yellow axis) although other abnormalities are occasionally seen. Tests have been conducted by Fishman et al. which showed that no single patient with a visual acuity of less than 20/30, had normal colour vision. [7]

6. The visual field shows what a person can see from all parts of the eye when looking straight ahead at a fixed point.

7. Heckenlively R, *Retinitis Pigmentosa*, p. 14.

All types of RP are inherited genetically. As a group RP has common features although the diseases can be broken down into four individual groups classified by the mode of inheritance.

Autosomal Recessive Inheritance

Autosomal recessive inheritance is the most frequent form of RP which occurs sporadically in the family tree with some generations escaping entirely. Both parents must be unaffected carriers. The chances of the children (either sex) being affected are one in four. The chance of the unaffected brothers and sisters being carriers are two in three. It is estimated that one person in eighty carries the recessive RP gene.

Autosomal Dominant

Autosomal dominant is the second most frequent and usually the mildest form. Some families have numerous cases which occur in every generation. Either parent can be affected. The chances of children (either sex) being affected are one in two. In this case RP is usually prevalent in every generation. A study by Fishman, evaluating central vision loss in 174 RP patients found that the degree of loss was mildest in autosomal dominant RP and most severe in X-linked recessive patients. [8]

8. *op. cit.*, p. 79.

Sex Linked Recessive

Sex linked recessive is the least frequent form. Fathers can be affected or mothers can be carriers (although sometimes minimally affected.)

If the father is affected ; -ail sons will be unaffected

-all daughters will be carriers.

If the mother is a carrier;-one in two sons will be affected.

-one in two daughters will be carriers

Sporadic Retinitis Pigmentosa

Sporadic RP arises through a spontaneous mutation of the genes where no previous family history of RP has been recorded. It can be the beginning, in a particular family, of any of the types of RP described above. [9]

5.3 Symptoms of Retinitis Pigmentosa

The various types of disability associated with RP are often classified together although they can be categorised separately according to the differences in their characteristics.

Classic Tunnel Vision,

In classic tunnel vision, the central vision has a field of less than 7° in diameter. The extent of the defect is present to almost the same degree in both eyes. In some cases the loss in vision stagnates for an indefinite period but the more usual course is relentless progression. Sufferers in this group can execute tasks in a familiar environment and read competently.

9. Adapted from the leaflet, *Save My Sight,* RP Ireland-Fighting Blindness.

Their main risk is from their lack of peripheral vision when outdoors. Peripheral loss of vision is not easily identified and a person may be able to read perfectly for years yet experience considerable difficulty when moving around. Studies by Zamier and Berson with patients who had X-linked RP (and various other studies on cone spatial density) strongly suggest that there is such a high density of cone cells in the fovea that even with a loss of 50% of foveal cones, vision can remain close to normal. [10]

Central Scotoma Type,

With this type of RP, there is a relatively good visual field of between 30° and 40° or more. Sufferers in this group require help from devices when reading.

Cataracts,

Opacities cause a degeneration of the image from the retina. Vision will be inadequate for normal reading and the smallest type size for print will begin at 36 point.

Light Adaptation Problems,

Adaptation to various lighting conditions is particularly important for a person with RP. Light adaptation problems can be sub-divided into two parts: firstly, there can be a lack of function in the rods in advanced cases of the disease. The main symptom is night blindness in dim to dark environments. Night blindness is common in most types of RP and is often noticed by sufferers within the first year of the disease.

10. Heckenlively, *op. cit*,. p. 77.

The second category is abnormal cone adaptation which causes profound brightness outdoors on a bright day, or problems with adjusting to badly lit areas. The process of adaptation is achieved through the different qualities of rod and cone cells and the ability of the pupil to control the amount of light entering the eye. [11]

In low light the rod cells, which are situated on the periphery of the retina, are activated and the pupils dilate, yet in bright light the rods become insensitive and the pupils contract. The cone cells operate in reverse of the rods. Since RP cause degeneration of the retina from a point midway in its periphery, the rods are affected and this leads to night blindness. [12] Loss of efficiency in reading may be due to unsatisfactory diffusion of light because of glare from glazed objects or a highly reflective surface that is within the eyes field of vision. Problems with light adaptation are most obvious with mobility.

RP can be associated with single or multiple organ system disease. The most common secondary form of disease associated with RP is Ushers Syndrome. This is a dual sensory impairment which is progressive in nature and is a major cause of deafness amongst adults. [13] Bardet-Biedl Syndrome, Abetalipoproteinemia and Senior-Loken Syndrome are other secondary forms of RP.

11. RP symptoms are adopted from Heckenlively, *op. cit.*, p. 96.

12. *Information Sheet IS4.I: Assessing Visual Abilities*, Module 1-Unit 4, R.N.I.B., 1996, p. 93.

13. Mason, *Spotlight on Special Educational Needs; Visual Impairment*, p. 29.

All RP conditions are progressive but the speed at which deterioration takes place varies from person to person. In certain cases the RP sufferer might not experience an advanced stage of the disease and hence can retain a small area of useful vision well into old age. Ehrlich writes, 'One could assume that RP patients whose visual loss is gradual could adopt new eye movement patterns to compensate for their field loss when provided with reading matter of appropriate contrast and size.' [14]

Loss of sight changes a persons life and one of the most distressing effects is associated with an inability to read. The ability to read is crucial to the ability to function effectively to any degree in our society, as we read primarily for information, social development, political awareness and entertainment. 'Reading disabilities from medical causes are far more common, of course, than total blindness or inability to move about safely.' [15]

14. D. Ehrlich, A Comparative study in the use of Closed-Circuit Television Reading Machines and Optical Aids by Patients with Retinitis Pigmentosa and Maculopathy, *Ophthalmology and Physiological Optics*, p. 294.

15. Gardiner, P. A., 'Medical Aspects and The Particular Problems of Adults.' in *Print for the Visually Handicapped Reader*, 1970, p. 8.

Even people with generally poor eyesight scan several words on a line when reading and depend on peripheral vision to help them to do this. Due to the contracting visual field, sufferers of RP who loose the outer fringes of their vision must contend with a number of difficulties when reading. A misguided perception of space can lead to tracking problems as the reader can not see enough to keep their place on a line while reading a page of text. A choice has to be made, either to move the head to aid scanning or else to hold the book close to the eye and move it across the field of vision by hand. Either way the reality is that reading is not such an enjoyable experience and it is a much slower process than for normal sighted individuals.

The effect of RP has been likened by one RP sufferer to 'looking through the keyhole of a door.' [16] For a person suffering from this disability, learning to use their visual clues intelligently and being aware of the limitation of their vision will help to improve some of the problems associated with reading. [17]

16. Quoted by Carol Brill, R.P. sufferer and chairperson of RP Ireland Fighting Blindness from a television documentary entitled 'She's Brill, A year in the life of Carol Brill and Alistar Doran', transmitted on RTE tv on Thursday 26th of March, 1988. The programme was filmed over 18 months and focused on RP with particular attention being paid to Ushers Syndrome.

17. Ref. Appendices G & H for interviews with RP subjects on the personal effects of reading with RP.

Chapter 6

Factors That Influence Legibility

6.1 Readability and Legibility; An Explanation.

Legible-adj. clear enough to be deciphered, readable.

Readable-adj able to be read; interesting to read. [f.read]

-Oxford Reference Dictionary Definition

The differences between legibility and readability are frequently misunderstood. Legibility, which is often in conflict with readability, does not have the same implications.

Readability in contemporary books and literature refers to the style, grammar and complexity of prose, a quality which promotes interest, pleasure and challenge in reading.

Legibility is a quality of efficient, clear and simple reading. It is not just a matter of being able to read a text but to be able to read it with minimal strain on the eyesight and it is very important in the case of voluntary reading.

6.2 Readability.

Readability is in a sense the art of matching the reader to the most appropriate choice of text. Certain reading material will have significantly different demands on reading skill level. A competent reader may soon be discouraged to read if a text is too simple or repetitive, or otherwise a person with limited reading ability is deterred if a text is beyond their comprehension. If a person particularly wants to read a text they will read it regardless, on the other hand if the text refers to a subject the reader has no interest in, they are likely to find it unreadable irrespective of its legibility.

There is a difference between reading disability due to educational standards and reading disabilities due to vision anomalies. Reading disability can occur in the absence of significant vision problems, whereas discrepancies in vision can either be a dominant factor or merely a contributory factor to the growth of reading disability.

Conversely, not all persons with vision problems develop reading disabilities although it can be a contributory factor that exacerbates the problem. A normal reader has an effortless ease in eye control and word perception, which is known as 'automacity'. Automacity does not occur during reading if a person has ocular discomfort.

The basic concept of readability is the relationship between the readers perceptual skills and the printed characters which they see and read. There are three aspects to the reading process and each measure relates to a different reading skill.

- Fluency and ease of reading are measured by word recognition speed, error rates and the number of eye fixations per second.

- Readability as human interest, refers to the content of books and the reader's interest in the range of vocabulary. This measure involves subjective judgement and it is the means by which most personal assessments of the readability of books is judged.

- Comprehension refers to the characteristics of words and sentences, defined by word length, the complexity of sentences and the frequency of word occurrences. [1]

6.3 Legibility

Opinions among designers tend to differ regarding legibility. In 1991 Phil Baines, British typographer and letterpress exponent conveys that 'Legibility is anything that is clear enough to read.' [2]

Eric Gill expressed in 1931, 'Legibility in practice amounts to what people are used to.' [3] Peter Merten, 1990, states that 'Letters are legible. If somethings are not legible then they are not letters. Illegible letters do not exist. Illegibility does not exist.' [4]

1. High. C. R., 'The Art of Design for Legibility' for Tenex Software Engineering of Olympia, Washington, USA, 1995-1997, (02/04/98) Page 9 Http//www.halcyon.com/chigh/artlegw.html

2. Baines, P., 'Clear Enough To Read', *Emigre*, Issue 18, 1991.

3. Gill, Eric., *An Essay on Typography*, London Sheed and Ward.

4. Mertens, P., *Emigre*, Issue 15, p. 4.

There are numerous publications, books, articles and references from records dating back to 150 years ago with various definitions on legibility. More recent legibility studies are concerned with the problems of reading disability and modern methods for the visual presentation of information. Optimal legibility referred to in this thesis, is achieved by transmitting correct design arrangements, ensuring minimal strain on the eyesight. The designer must be aware of who the target audiences are and the purpose of the design, why is it to be read, and when and where it will be read. [5]

Legibility covers a wide territory and it is as much a matter of psychological factors, as physical factors. The physical aspects of legibility include size, distance from the eye, illumination [6] and the background surface of the letters. Legibility also depends on the context in which text is perceived and the physical capabilities of the reader. There are a number of factors that are said to contribute or detract from the general legibility of print:

• Readers expectations concerning subject matter clearly influences both the threshold limits for reading success, and the tolerance for exceeding this limit. If a reader is aware of a difficult subject matter, a much higher level of reading frustration is tolerated. Conversely, the more interested a reader is in a subject, the more they will tolerate or ignore physical factors, regardless of its legibility.

5. Mc Lean, Ruairi., *The Thames and Hudson Manual of Typography*, Thames and Hudson, 30 Bloomsbury Street, London, 1980, p.42.

6. The brightness and quality of light under which the letters are read.

• Familiarity with material and the previously acquired vocabulary of a reader can determine the speed at which text is read. Reduced speed of reading is a good indicator that legibility standards are also failing.

• A fundamental skill associated with reading on all levels is attention. Senses are dulled when the reader is fatigued or discouraged from reading material outside the normal areas of the reader's interest, thus interfering with the processing of information required for successful reading.

• Kolers 1969, discussed the importance of the visual decoding of letters. Ascenders are more important than descenders for recognition, because the upper half of letters give more visual clues than the lower half. This statement is equally true for upper case letters.

> Typefaces that emphasise bold down strokes for the Roman alphabet impede their smooth visual processing, so that the typeface designer should concern himself with the distinguishing marks of letters. Equally if reading from left to right, the right hand side of the letters are more informative than the left hand side because the right field is better at processing words than the left field. [7]

• Health issues including age, perception capacity, well being, visual acuity and the general environment will have an impact on the capabilities of the reader. [8]

7. Kolers. 'Clues to a Letter's Recognition; Implications for the design of Characters', *Journal of Typographical Research* 3, pp. 145-168.

8. High. C. R, 'The Art of Design for Legibility' for Tenex Software Engineering of Olympia, Washington, USA, 1995-1997, (02/04/98) Page 9 Http//www.halcyon.com/chigh/artlegw.html

6.4 The Reading Difficulties of Sight Impaired Readers

Sight impaired readers have erratic, irregular and inconsistent reading behaviour that causes difficulties when reading. There is considerable variation in the number and occurrence of individual fixations (periods of clear vision) and regressions (backwards moves within a line to re-examine material), in which perception occurs in different reading circumstances. The inconsistencies relate to various typographic factors including the readers experience, text difficulty, spacing, print size and also the content of the reading material. [9]

The significance of visual attention in reading eye movement is related to the concept of perceptual span. Perceptual span is the number of words that are perceived during each fixation and can be calculated as the number of words read, divided by the number of fixations. Adults have a much larger perceptual span than children and sight impaired readers. More proficient readers use spatial information, word shape and line length to increase their perceptual span. If the number of fixations are increased, reading becomes a more tedious process and hence has adverse affects on the reader's attention span. Rayner, K., undertook a study using a moving window to restrict the field of vision to only five characters and found that reading rate was reduced by 38% in beginning readers and 65% in adult readers. This test relates categorically to the limited vision experienced by RP readers. [10]

9. Garzia, R. P., *Vision and Reading*, p. 135.

10. Garzia, R. P., *Vision and Reading*, p. 137.

The most obvious differences in reading behaviour incurred by sight impaired readers are an increases in the number of fixations and the longer duration of each pause. Saccade lengths (quick jerks from one fixation to another along a line of print) are shorter in length and there is generally a higher proportion of regressions than for the sighted reader. A further noticeable inconsistency is an increase in the amount of refixatings that are recorded. [11] A number of case studies have demonstrated that some sight impaired readers have particular difficulty with the programming and execution of return sweep saccades. [12]

> Where to move the eye is based on low level parafoveal visual perception information that uses the spaces between words to calculate word length and hence saccade length. There is a preferred landing site for the first saccade on a word. This preferred viewing position just falls left of the centre of the word. The goal of the saccade is to land in the optimal position for the fastest word recognition. [13]

Most fluent readers do not read word by word but rather line by line. Speed is based on word recognition through word shape rather than individual letters. The skilled reader scans lines of text rapidly and can skip small words and vowels, without interfering with comprehension. For partially sighted readers, who already confuse very visible letters, there is considerably more emphasis placed on individual letter and numeral recognition and hence typefaces must be of an appropriate size and typographical standard for perception to occur. Terry et al. 1967, have suggested that letter by letter processing may be used by less skilled readers, while fluent readers may use the whole word. [14]

11. Refixating refers to the inability to identify and recognise a word on the first fixation point and the reader is forced to make a short saccade to a further rightward position of the fixated word in order to identify the word.

12. *op. cit.*, p. 135.

13. *ibid.*

14. Reynolds, L., "Legibility of Printed Scientific and Technical Information", in *Information Design: The Design and Evaluation of Signs and Printed Material*, ed. Ronald Easterby and Harm Zwarga, John Wiley and Sons Ltd, 1984, p.192.

Before any significance can be attached to a single letter or sequence of letters, they have to be perceived and then recognised. The distinctive feature of letters depends on the graphic content of the word, the adjacent letters and the visual components in the design of characters.

- The nature of ascending and descending letters.
- The presence of serifs or spurs.
- The smoothness and slope of a letter.
- The white space enclosed by a letterform, whether wholly enclosed or partially.

Little is known about the impact of a font for low-vision readers. There are few studies that have directly addressed how typeface effects low-vision reading. Mansfield, Legge and Bane 1996, write,

> There is reason to suspect that low vision reading may be particularly sensitive to font. For example, crowding effects purportedly are stronger in peripheral vision, raising the possibility that people with central field loss, who use peripheral vision to read, would be at a special disadvantage reading a font with tight letter-to-letter spacing. [15]

15. 'Crowding' is the close proximity of adjacent letter in proportionally spaced text. This definition is adopted from Mansfield J. S, G. E. Legge, and M. C. Bane, 'Psychophysics of Reading XV: Font Effects in Normal and Low Vision', *Investigative Ophthalmology & Visual Science*, vol. 37, p. 1499.

Refer Appendix D for a full report on the Tiresias Screenfont Http:// www.tiresias.org/font/design_report_sf.htm

6.5 Factors that determine the legibility of text and a number of characteristics that should be avoided.

There are at least two different ways of understanding individual typefaces. Firstly, there is the practical, utilitarian aspect whereby arranging the individual letters into words and words into sentences, makes a linguistic message. Context is everything in order to convey a simple and understandable meaning in a clear and concise way. The second is the aesthetic aspect of a type design that expresses the alphabet visually. In fact, there are many typefaces that have artistic features which diminish the utilitarian aspect of a font and override their ability to communicate linguistic messages effectively. [16]

When choosing a typeface, the designer must first decide exactly what is intended to communicate and then to consider what style of lettering best suits the design. An appropriate choice of typeface is extremely important to a designer, because the value of differentiation that a particular typeface brings to a design over another typeface can considerably influence the message. Legibility is increased by letters that are clearly distinguishable from each other. This requirement exerts a restraining influence on the design of the font, as the 'personality' or outward look of a legible typeface is often rendered almost transparent to the reader. There is a definite limit to the amount of manipulation and distortion that letters undergo before they become illegible.

16. Adapted from Vanderlans. R., 'The Trouble With Type', *Emigre*, Issue 43, p. 12

6.6 The Legibility of Typefaces.

Comparisons of typefaces in prose have been reported since the beginning of legibility studies but measurable effects on reading performance are quite rare. For a given typeface, its legibility depends firstly on its inherent qualities and secondly on the way the typeface is used. Legible typefaces rely on a number of design characteristics as discussed below.

• Open counters (the enclosed white space of letters) define individual characters. A byproduct of open counters is usually a large x-height which tends to aid legibility. Small typesizes require open counters to avoid the risk of 'filling in' occurring. If letters are printed in dark, dense ink, then inevitably the spaces enclosed by each letter are reduced, hence diminishing word recognition. A large x-height, often indicates open counter forms. An excessively large x-height with short ascenders and descenders causes a less defined word shape and consequently a loss of definition. Certain single letters, lower case d, m, p, and q and have a high degree of legibility but lower case c, n, i, l, and e are considerably less legible. [17]

• Numerals are read digit by digit and are more difficult to read than words. Partially sighted readers often misread the numerals 3, 5, 6 and 8, therefore it is important that typefaces are chosen for their distinct numerals and they should have optimal height-width proportions. Ambiguities between letters and numerals are most evident in sanserif fonts and therefore it is more plausible to use typefaces with serifs to enhance the numeral. [18]

17. Haley, Allan., FYTI For your Typographic Information, Legibility and Readability (Part 1), *Upper &Lower Case.*

18. Long/Garzia, Wingert/Garzia., *Vision And Reading* Ergonomics of Reading, p. 91

Tinker, 1930, concluded that old-style digits (which vary in height and alignment) were slightly more perceptible than modern but were markedly more easily identified when in groups. In terms of perceptibility at a distance, old-style digits were also favoured. These results influenced the choice of non-ranging numerals for Revised Optima. [19]

• It is important that typefaces have reduced variation between thick and thin strokes, as fine strokes may be invisible to a person with low vision. It also follows that thickening strokes to any excessive degree will reduce the size of the enclosed areas of white space. Abrupt changes in type weight, often a characteristic of the typography seen in glossy magazines are confusing and break the even flow of text.

• Typefaces should have long ascenders and descenders to aid word shape recognition. Longer ascenders and descenders are vital for ease of reading, however exaggerated forms draw attention to themselves and they do not blend with the surrounding type. [20] 'The ascending letters b, d, f, h, l and t, and the descending letters g, j, p, q and y, split up words and frequently these divisions correspond with the syllabic compositions of the words, thus making for easier reading.' [21]

• Type weight is an important factor for visually impaired readers. Heavier faces tend to be more suitable than lighter weights of type, although excessively heavy weights are not recommended as they lessen the ability to differentiate character shapes and at small sizes the counter forms of bold letters fill-in. For continuous text, a semi-bold version, which lies between the basic Roman form and a bold form is the most legible type weight for the sight impaired reader.

19 Tinker, M.A., *Legibility of Print*, p. 39.

20. Ascenders are strokes which rise above the x-height and descenders are strokes which drop below the base line.

21. Evetts, L.C., *Roman Lettering*, p. 10.

• Type size of 14 point or smaller is equivalent to text type. Larger font sizes are called display or headline type. Selecting the appropriate type size is an important factor for ease of reading for the sight impaired reader. John Block, compared the oral reading performance of visually impaired readers on 12 point & 18 point type with and without magnification. Magnifying standard print led to poorer reading performance. Overall the 18 point type was not superior to the 12 point type but Block suggests that larger type may be better for some kinds of visual impairment. [22]

In October 1993, the RNIB launched a new look for their magazine publication 'New Beacon'. For the first time the body text of the print edition appeared in 12 point RNIB New Baskerville. This typeface was created following research by the RNIB on clarity and legibility and from the results of an extensive readers survey on the needs of blind and partially sighted adults in Britain. General improvements were made in the various sections of the magazine also in response to the readers survey. The improvements related to name changing and rationalisation in the various sections of the magazine. [23] 'The choice of New Baskerville was relevant because it has a classic, timeless look appropriate to the work of the RNIB and it comes in a good range of weights which add to the flexibility of its use.' [24]

22. Block, J., 'Reading Performance of Visually Impaired Print Readers using Standard Print, Large Print and Magnification', 1977.

23. Adapted from the editorial introduction of New Beacon RNIB magazine, October 1993. Attempts were made to source the original survey but it appears that this information is not available. Email from John Gill, Chief Scientist RNIB, 'I have not seen any report on the research leading to the adoption of New Baskerville. You could ask the RNIB Research Library if they have a copy'. Wed, 31 May 2000. JGill@rnib.org.uk
'I am afraid our records from this period are not very good and this research , if it was infact ever done, was not properly kept and it is not therefore available'. Ben Milbank, Senior Graphic Designer, 2 June 2000 bmillbank@rnib.org.uk

24. Hilary Todd, RNIB Publications Manager, a letter to 'Professor Michael Twyman', 27 April 1993, from Reading University, Department of Typographic and Graphic Communication.

The survey showed that many more partially sighted people could read print if it was a reasonable size and well designed than researchers had previously considered, which highlights the lack of awareness and misjudgment associated with design for partially sighted readers.

6.7 The Use of Capitals and Lower Case Letters

Varying heights of lower case letters; x-heights, ascenders and descenders when combined to form a word, create an outline shape or pattern which is stored in the memory of the reader. The Gestalt theory states, that we tend to group things in order to make a pattern and complete shapes. It has been proved that word shape is an aid to recognition and it is a prerequisite of fluent reading. A sighted reader generally does not read each word individually but predicts the meaning of a sentence primarily by recognising the overall shape of the words, the sentence structure and the overall context. [25]

Owing to the nature of the disease, and as a result of interviewing subjects, it was found that individual letter legibility becomes as important as the legibility of the whole word for RP sighted readers whose visual acuity has diminished to three or four letter recognition. Without the aid of ascenders and descenders, uppercase letters force the reader to read individual letters and combine the letters into words. Spencer reports on tests performed by Breland and Breland, Paterson, and Tinker and Starch all who showed that text set in capitals are read considerably slower than upper and lower case text.

25. Ehrlich, D., 'A Comparative Study in the use of Closed Circuit Television Reading Machines and Optical Aids by Patients with Retinitis Pigmentosa and Maculopathy,' *Ophthalmology and Physiological Optics*, vol. 7, p. 296.

Tinker reported on investigations in which 60 college students read material for reading periods of 5, 10 and 20 minutes in both capitals and upper and lower case. He calculated that the percentage loss of speed during each period when reading capitals was between 9.53 and 19%. Tinker concluded from this data that all capital printing retards speed of reading and most readers consider lower-case print faster and easier to read. [26]

A number of reasons for setting type in upper and lower case are as follows;

• Over 95% of the text compositions we are exposed to are set in lower case letters. The importance of familiarity provides a basic argument for the use of upper and lower case letters. Continuous text set in capitals is considered less legible than text set in upper and lower case because we believe that we read best what we read most. Eric Gill in 1903, expresses this notion perfectly, 'Legibility, in practice, amounts simply to what one is accustomed to.' [27]

• Lower case typography requires up to fifty percent less space than text set in capitals. As a result, fewer movements are made by the eye in order to observe the same amount of information set in uppercase.

• Lower case letters are easier to recognise than capitals because they have clear definition in terms of shape and size and they have more varied distinctive features. [28]

26. Tinker, M. A., *Legibility of Print*, pp. 57-58.

27. Spencer, H., *The Visible Word*, p. 11.

28. Tinker, M. A., *Legibility of Print*, p. 60.

Capitals take precedent over lower case text when the characters of a particular typeface are very similar and their combination impedes accurate perception. The letter i, l and the numeral 1, are undistinguishable from one another in certain sanserif fonts, so too can be the letter o and the numeral 0. To use the example of the word 'illegibility' set in both upper and lower case and in capitals, the combination of letters may be easier to perceive in capitals than the word in upper and lower case. [29]

Poulton's research on the legibility of medicine bottle labels shows that capitals are more easily discriminated at smaller sizes than upper and lower case letters of the same size. [30]

29. The above factors are adopted from, Haley, A., All-Caps, A typographic Oxy-Moran, *Upper and Lower Case*, Fall 1991, p. 15.

30. Poulton, E.C., 'Identifying the names and dosage of drugs.', J Pharm, *Pharmacol.*, 1964 16, p. 213.

6.8 Serifs

Studies on the preference for sanserif fonts and serif typefaces are useful in providing general bases for legibility studies, however the subjectivity of replies reduces the usefulness of these conclusions. Researchers have been unable to confirm whether the choice of sanserif or serif typefaces are significantly more legible. Generally adult readers are more exposed to reading serif typefaces and therefore they are often preferred.

Tests with partially sighted children conducted by Donald Harvey suggest that at a particular size and with appropriate typographical standard, sanserif fonts and serif fonts are read equally well. [31]

• Serifs link letters into cohesive patterns to form recognisable word shape, [32] and their horizontal emphasis guides the eye along each line. They allow letters to be spaced more openly which makes individual letter shapes more discernable. The space between letters must be sufficient to separate them clearly from one another. If serifs are overly long, heavy or have exaggerated shapes they will detract from individual letter legibility. [33]

31. Harvey, D., 'Partial Sight', *The Monotype Recorder*, vol. 43.

32. Long/Garzia/Wingert/Garzia, *Vision and Reading*, The Ergonomis of Reading, p. 92

33. Reynolds, L., 'Legibility of Type', *Baseline* (Date unknown)

• Serifs are more useful than sanserif fonts for distinguishing between certain letters of the alphabet particularly the upper half of letters. Messmer 1903, proved that the 'dominant letters in a word are those which project above the line' because the upper half of lower case letter sfurnish more clues to a word form than the lower half. [34]

• An argument against serif fonts is that they tend to have a considerable variation within the strokes of the letterforms. In bad light or equally after poor photocopying, thin letter strokes can disappear, leaving only partly visible letters. [35]

One cannot say that sanserif typefaces are intrinsically less legible than serif typefaces but there are certain factors that may influence the choice of style. Ambiguities do occur when trying to decipher words especially in the lower case alphabet of a sanserif typeface for example. lower case r and n when placed close together forms the letter m. Context does not always eliminate the problem especially if another legitimate word is formed, quite different from what was intended. Contrary to this, Reynolds, L., writes that there is evidence to suggest that sanserif fonts are the most legible for children and poor vision readers, and they are widely accepted as being suitable for display purposes because of their simple form. [36]

34. Spencer, *op. cit.*, p. 14.

35. The following statement is by Margaret Singerman, a sufferer of Macular Degeneration, in a letter to 'Professor Michael Twyman', 20 February. 1995.
'If your eye condition only allows you to read part of the letter at a time then the addition of serifs, only further confuse the reader.' In a progressed state of the disease R.P., it is normal that only parts of a word is visible at any one time. It is possible therefore that sansenf fonts are more appropriate for partially sighted readers because their shapes are simpler especially for individual letter reading.

36. Reynolds, L., 'Legibility of Printed Scientific and Technical Information', in *Information Design: The Design and Evaluation of Signs and Printed Material*, ed. Ronald Easterby and Harm Zwarga, John Wiley and Sons Ltd, 1984, p.198.

6.9 Spacing

Typographical space not only refers to letter spacing, word spacing and line spacing but also the general arrangement of type on a page. Spacing aids the readers perception of the structure of a document and it highlights any inconsistencies in a text.

The key to good letter spacing is consistency. Optimum letter spacing in body text has a uniform grey tone to the page, often referred to as 'even typographic colour'. If the letter spacing is too open, white spots form throughout the text. Alternatively, letter spacing that is too tight causes black spots to appear where letters are too close and as a result they touch, which distract the reader and equally interrupt the smooth flow of reading.

Generally longer lines need increased spacing between letters and between sentences. Obviously, the space between words must be much greater than the space between letters within a word, however the spacing must not be so great that the eye of the reader tends to wander from one line to the next without even reaching the end of the first line. If letter spacing is too open, the reader is forced to read letter by letter slowing down the speed of reading. Inter-letter spacing can be improved by the use of effective kerning [37] although requirements may vary throughout typefaces and even within the same typeface family.

37 A classic definition of kerning is, the selective reduction of white space between irregular shaped letters to create even optical spacing in a line of text.

6.10 Kerning

Numerous studies have shown that kerning does not necessarily improve reading speed or comprehension and kerned text is rarely noticed by the reader. Kerning is however, an important factor to consider specifically when enlarging type for the sight impaired reader. When type size increases, tighter kerning is required to facilitate the grouping of letterforms into words and to create even optical space in a line of text.

Below are a general set of guidelines by Alan Haley, indicating when kerning is required, in printed design. [38]

- Commas, periods and quotes always have to be kerned.

- Capitals and lowercase letters with outside diagonal strokes require kerning more often than not.

- The uppercase letters T, L & P generally need to be kerned with non-ascending lowercase letters.

38. Haley, A., 'Kerning, Fine Typography or Marketing Hype', *Upper and Lower Case*, p. 22.

6.11 Line Length

A considerable amount of research has been devoted to establishing optimal line length. Research has proved that sentences of 60-70 characters, about 10-12 words are the most legible for sighted readers. Line length cannot be determined independent of type size and typeface. A key factor to the efficiency of reading text for the RP sighted is to keep line length relatively short. This is important to ensure correct use of a narrow field of vision and to avoid passages of text that are wider than the readers comfortable eye span. Wider columns of text require the reader to move their head slightly, or strain their eyes muscles to track over the longer lines. Conversely, narrow columns of type can create many awkward breaks in the text and if the type is justified, there may be too much hyphenation.

Longer line length requires more line increment (inter linear space) than shorter lines because the eye has difficulty returning to the beginning of the successive line in a wide body of text. The eye also loses track of its position when there are too many words on a line and the reader needs to re-read the sentence. This condition is known as 'doubling' or regressions and has a limiting effect on the reader's attention span. It is essential that typefaces with a strong vertical emphasis i.e. long ascenders and descenders, have sufficient line increment to avoid adjacent lines of type pressing together. Conversely, if there is too much line spacing, not only will the text appear lighter in colour and drift apart, but the eye has trouble making the jump down to the next line of type.

6.12 Text Alignment

There is little scientific evidence to suggest that either justified or unjustified text has a significant effect on legibility. [39] Justified text to both margins is often preferred because of its neat appearance and because the eye becomes familiar with returning to a common point. This arrangement of type is regularly used in books, newspapers and magazines, because of the economic considerations of printing large amount of copy. Justification plays havoc with spacing on a page of enlarged type with a limited copy. It is also not suitable for columns that are too narrow because of the need for hyphenation and letter spacing becomes overly tight. Justification is especially confusing for sight impaired readers, as letters are sometimes spaced very close together, which inhibits word-shape recognition. Tests conducted on justification by Zachrisson, Bror at the Graphic Institute in Stockholm found that the least proficient readers in his sample of 24 females and 24 male readers, read unjustified text quicker than justified text. [40]

The R.N.I.B. recommends in their publication See it Right, Clear Print Guidelines the use of unjustified right hand margins [41] and it would appear from evidence collected by Powers, S.P. 1962, that less skilled readers find unjustified text easier to read. [42]

39. Spencer, *op.cit.*, p. 37.

40. *ibid.*

41. *See It Right, Clear Print Guidelines*, R.N.I.B Publications Http://www.rnib.org.uk/seeitright/why access.htm

42. Reynolds, L., *op. cit.*, p. 203.

The most obvious reason for using unjustified text is that it allows for even word spacing and it prevents unnecessary word breaks and the over-use of hyphenation at the end of lines. Word breaks that occur directly below one another join optically to form vertical rivers, or lines of white that break up text and destroy continuity.

6.13 Page Design

The arrangement of type elements and column width are the first things that a reader observes when they view a page. The reader's eye scans the page firstly as a purely graphic pattern and secondly begins to decode the different elements of typography. Typographic continuity can help the reader to organise and establish the location of information into a familiar pattern. Paper size effects the number of columns, line length, type size and line increment.

The most important factors of page design are; clarity of layout and consistency of spacing to reflect the structure of the text. A well designed page layout will lead the reader in a more structured manner, to faster, more accurate location of information. Patchy, inconsistent blocks of text, makes finding the typographic cues that guide the eye to the whereabouts of information, difficult for the reader. [43]

43. The Yale Style Manual, Typography II, Pattern and Page Design, On line Reference, (1/27/98) Http://daikon.tuc.noao.edu/caim/pages/typography2.html

6.14 Single Versus Double Columns

Information on a page can be treated either in a one column layout or divided into two or more narrower columns. Text set in a two column grid should have sufficient intercolumnar margins and adequate space on the edges of the page to allow for handling. Two or more columns present a more functional and visually appealing layout and allow for smaller type sizes to be used without the lines becoming overly long. The effect of reading either single or multiple-column print relates to legibility issues of type size, optimal line widths, and line increment. Reader's preferences are clearly for the double column presentation. [44]

Results obtained from testing paragraph denotation in single and two column text, by J. Hartley and P. Burnhill 1976, indicate that a two column layout is slightly preferable to a single column one, for the setting of straightforward prose on an A4 page. In terms of cost effectiveness, a two column grid is more space effective and it is possible to get more words on a page with a two column layout. [45] Tinker also conducted studies on 241 college students with samples of single and of double column layout. 60.5% of the group ranked double column as their preferred printing arrangement. [46]

44. Garzia, R. P., *Vision and Reading*, p. 95.

45. J. Hartley, 'Space and Structure in Instructional Text', in *Information Design: The Design and Evaluation of Signs and Printed Material*, ed. Ronald Easterby and Harm Zwarga, John Wiley and Sons Ltd, 1984, p. 512.

46. Tinker M. A., *Legibility of Print*, p. 118.

The process of vision recognises the edge between contrasting figures against their background. Most printed material has a light coloured background with dark print. It is generally assumed that a person suffering from a vision defect will see reduced contrast in the colours than a sighted person can see. By exaggerating the differences between light and dark colours, the problem of reading is eased. In addition, colours with a similar hue or otherwise sharply contrasting hues like green on red are particularly difficult to read and should be avoided. For good legibility, the contrast between type and its background should be at least 70%. [49]

Black type printed on white or yellow paper is more acceptable than coloured inks on paper, and is considered the strongest combination for optimum legibility, providing other typographic factors are suitable. The photo-receptors in the retina are stimulated only by light. Bright colours reflect more light which results in excessive stimulation of the eyes White reflects about 80% of light while black reflects only 5%. [50]

Tinker 1963, showed that in normal reading situations, black ink on white paper has over 10% more reading efficiency than the reverse. [51]

49. Reynolds. L, 'Legibility of Type', *Baseline.*

50. Morton, J, L., *Colour and Vision Matters,* 1995-1997. Http://www.lava.net/colourcom/optics.html

51. Reynolds. L., 'Legibility of Printed Scientific and Technical Information', in *Information Design: The Design and Evaluation of Signs and Printed Material,* ed. Ronald Easterby and Harm Zwarga, John Wiley and Sons Ltd, 1984, p.205

In a typical combination of black type on a white background, the letters are surrounded by white space that reflects light off the page. This reflective light activates the rods and cones whereas the letters being non-reflective are non-activatory. Owing to the structure of the eyes and the optic nerve, white shapes are transmitted to the brain slightly larger than their actual size, thus white type on a black background appears bigger than the reverse. Similarly, it is the enclosed white shape, or counters and not the letters that control the perceived width of a figure. Therefore in a combination of white type on a black background, the white type will appear bigger than its actual size.

White areas immediately surrounding black shapes appear whiter or brighter than the page itself, giving off a type of halo or illumination. The combination of halos and optical white shapes are part of a process which is referred to as 'irradiation'. The nerve supply at the periphery of the retina is more sparse than at the centre of the retina, thus the optical expansion of white shapes is greater at the centre of vision. Halos are more intense at the centre of vision, thus distorting that part of the letterform upon which the centre of vision is focused. Normally the eye focuses on the upper half of letters, in order to see all parts of the letter equally well and because the upper half of letters carry more information, hence it is this area that is most affected by irradiation. The size and brilliance of illuminated areas depends upon the contrast of the forms i.e. heavy black shape will have a more brilliant halo. When this principle of irradiation is adapted to dense, black type, it tends to cause after images that are noticeable as bright, glowing areas between lines. [52]

52 Gates, D., *Lettering For Reproduction*, p. 38

A light coloured typeface set in a small point size, printed on a dark background, has a tendency for the counterforms of letters to fill in and reduce legibility. This is due to either, the process of irradiation, or to ink that spreads during printing.and is not recommended. To counteract this effect, a typeface should have round, open counterforms and the letters should not be spaced too tightly together. The arrangement of dark on a lighter background is so common that it is not appreciated that the eye actually sees the background rather than the figure which is physiologically more appropriate. On the contrary, 'Some partially sighted people prefer reversed-out type if the size and weight are adequate.' [53] Anecdotal evidence suggests that coloured type rather than black type on a white background reduces the effects of glare for readers with RP. [54]

53. *See it Right-Clear Print Guidelines,* R.N.I.B. Publications. Http://www.rnib.org.uk/seeitright/whyaccess.htm
During the course of interviewing RP subjects who used computers in their profession, a number of comments were made that reversed-type was significantly easier for on-screen reading.

54. This statement was made by Michael Griffith, Director of RP Ireland-Fighting Blindness, during the course of successive interviews on the effects of RP.

Bror Zachrisson's report on certain typographic factors in relation to legibility and partial sight refers to several experiments using normal text size type that have shown that white text on a black background reduces legibility for normal sighted readers.

His own tests however, show that normal sighted readers whose vision has been reduced by filtered glasses found a negative text more legible than positive combination of text and background. In conclusion, Zachrisson believes that the factors which ascertain the optimum combination of text colour and background are determined by the size of the type. [55]

Salcedo et al.(1972) in their case studies on labels, reportedly found no difference in speed of reading or comprehension of black on yellow, black on white and red on green labels. However red on green was the least popular choice. [56]

After-images can occur with any colour however red on white is particularly noted for after-images. There are 250,000 colour decoding cones, 83,000 that are devoted to decoding the colour red. After focusing on this colour for a long period, the cones become fatigued and over stimulated and consequently the opposing cones become activated and a bluish/green after image occurs.

55. Zachrisson, B., and H. Smedshammar, 'Foretest Regarding Certain Typographic Factors in Relation to Legibility and Partially Sight' 1971.

56. Foster., J., *Legibility Research* 1972-1978, *A Summary*, p. 39.

Chapter 7

Testing Procedure

7.1 The Choice of Test Criteria

The key principle issues of testing, necessary to demonstrate were:

- What effect has typeface on the performance of RP sighted readers?
- Is this effect the same for normal vision reading?
- Are type size and column width important factors?
- How does the combination of type and background colour affect reading performance?

The choice of evaluation procedures adopted was an amalgamation of testing the interaction of the different criteria against subject performance and subject choice and establishing the order of priority of the separate factors. It was important that the testing method was valid and comparable to real-life situations *i.e.* challenging the accepted norms of print design and the hypothesis that 'bigger is better' for sight impaired readers. Equally, keeping the key variables within a manageable time limit for testing was necessary to create a performable test, thus avoiding subject fatigue. It was imperative to maintain this time limit because of the likelihood that subjects are unwilling to acknowledge their failing eye-sight and may have inhibitions about being interviewed in a test situation. A specification for the design of the test was that the typographic differences being tested should invariably be different in order to obtain objective measurable differences in performances.

By evaluating individual design elements and considering the nature of the vision deficiency associated with RP, it becomes clear that type size, typeface, page design and the contrast between colour of type and background are the macro elements that effect the legibility of printed material for RP readers. It was expected that these macro elements would provide reliable, valid information and indicate areas where a revised solution to current design practices would be beneficial for RP sighted readers. While design criteria such as type weight, serifs, spacing, letterform and choice of paper play an important role in print design, these factors do not appear to be the principal factors that affect reading with RP and for this reason they are not part of the test.

7.2 Preliminary Test

The preliminary test method was principally designed to refine legibility evaluation tests and procedures and to reduce the number of typefaces for further investigation. The criterion of the test was to rank in order of preference, the comparative legibility of typefaces. In addition subjects were asked to rate their preference for reading either sanserif or serif fonts. A diverse selection of five sanserif, one slab-serif and eight serif typefaces were selected by a dual consultation process. The fonts were selected on the basis of a literature survey of typographic manuals that documented and analysed the legibility of the various fonts and from the advice of a professional typographer. [1]

1. Examples of the 14 typefaces are given in Appendix F.

The initial 14 fonts were chosen in terms of their relative legibility and for their varying forms, keeping in mind that for visually impaired readers, it is the subtle structural differences in letters that can add or take away from the legibility of a font. [2]

The choice of test procedure is specific to the investigator's needs and in the case of this preliminary study, where readability was not the primary concern, it was considered sufficient to adopt an extract from the novel Animal Farm by George Orwell as the prose material for the preliminary test. This novel was chosen assuming that verbal ability would not be an influencing factor and that the text would be appealing for both adults and children. [3]

A target group of 45 subjects with normal vision volunteered to participate in the test. The group were non-randomly chosen but were considered to be broadly representative of the general population. Each subject was required to read the full set of fourteen texts consecutively, and the criterion was to rate the typeface alternatives, on the functional aspects of legibility and strictly not from an aesthetic judgement.

2. Previous test results have indicated that confusion between individual letters of the alphabet is aggravated by some features in the design of particular typefaces. Conversely, characters can be designed to emphasise individual features which promote rapid and accurate letter discrimination by the reader.

3. An overly challenging text can lead to a loss of concentration and interest, a consideration which must be avoided when testing typographic preferences.

The x-height of each of the 14 typefaces was compared systematically and standardised in order to make any kind of valid conclusions about type size and to eliminate a possible testing bias. X-height is important because it affects the visual impact of a block of copy. In 1903, Cohn and Rubencamp first drew attention to the importance of keeping the x-height constant [4] i.e. measuring the x-height of a typeface in physical size not point size. Typefaces of the same point sizes may have different x-heights and failure to recognise this results in invalid comparisons. The physical size for each typeface were measured equivalent to the x-height of Formata, 12 point. *(See diagram on next page)*

7.3 Preliminary Test Data Analysis

From a total of 45 participants, 56% of subjects preferred the serif fonts compared to 40% who preferred a sanserif setting.

Serif preferences	25
Sanserif preferences	18
No preference	2
Total N = 45	

Figure 1. Preliminary Test, Type Style Preferences

4. Spencer, H., *The Visible Word*, p. 27.

Typeface	X-height	Line Increment	Type style
Janson Text	14.50pt	17.5pt	serif
Arial	13.25pt	16.0pt	serif
Baskerville	15.00pt	18.0pt	serif
Bembo	15.75pt	17.0pt	serif
Cantoria	13.60pt	17.0pt	serif
Eras	11.25pt	16.5pt	sanserif
Formata *	12.00pt	16.0pt	sanserif
Ionic	11.50pt	16.0pt	serif
Gill Sans	13.90pt	16.0pt	sanserif
Optima	14.25pt	17.0pt	sanserif
Palatino	13.80pt	17.0pt	serif
Sabon	14.25pt	17.5pt	serif
Rockwell	12.90pt	16.0pt	slab-serif
Stempel	17.80pt	18.5pt	serif

* x-heights were measured equivalent to Formata 12pt

Figure 2. Preliminary Test, Comparative x-heights of Individual Typefaces, The diagram above displays the comparitive x-heights of 14 typefaces to the x-height of Formata at 12 point.

Overall results favoured the serif typefaces; Bembo (16.75) and Janson Text (16.25) were rated closely as the most legible fonts for text setting followed by Optima (13.25) and Arial (11.25). Rockwell (2.5) was immediately identifiable as the least legible typeface. Bembo, Janson Text and Optima all scored equally as a choice for first preferences with scores of eight each. [5]

5. Refer to Appendix E for subjects reasoning for identifying the above typefaces as the most legible.

Typeface	1st	2nd	3rd	4th	Total
Janson Text	8	8	4	1	16.25
Arial	6	6	1	1	11.25
Baskerville	3	4	3	2	8.00
Bembo	8	4	8	7	16.75
Italia	2	1	4	0	4.75
Eras	1	5	2	2	6.25
Formata	1	2	4	1	4.75
Ionic	1	1	0	2	2.25
Gill Sans	1	1	3	3	4.00
Optima	8	4	3	3	13.25
Palatino	0	2	5	4	5.00
Sabon	1	5	3	4	7.25
Rockwell	2	0	1	0	2.50
Venetian	4	2	3	2	7.50
Multiplied by	1.0	0.75	0.5	0.25	

Figure 3. Preliminary Test, Typeface Preferences ranked in order of 1st to 4th preference

The preliminary test provided an experimental basis from which the subjective legibility of fourteen typefaces could be evaluated and refined to form a basis for further testing with RP subjects. Furthermore it was an opportunity to analyse methods and procedures in preparation for testing RP sighted readers. As stated in 'An outline of the parameter of the problem', Part 1.2, the requirements of the sight impaired reader may differ only slightly from normal sighted individuals.

Donald Harvey, reinforces this hypothesis from his experience teaching partially sighted children. He found that the criteria of legibility, apply equally well to partially sighted children as normal sighted children. [6] Owing to the resistance of the macula to the degeneration process in the early stages of typical RP, it was thought that the factors that define a legible typeface for a sighted person would be similar to a person with RP. From this perspective, it was sufficient to use a large number of normal sighted persons to rank the sample of typefaces in order of relative legibility from the two main styles of font; sanserif and serif. Certain typefaces are generally acknowledged to be more legible for people with sight impairment, two of which were selected for specific evaluation. This data does not indicate that these two fonts have indubitably optimum qualities of legibility, but that s ubjects believe that Optima and Janson Text are are reasonably legible typefaces for prose settings.

6. Harvey, D., 'Partial Sight'. *The Monotype Recorder*, vol. 43., University of Reading, Department of Typography

In a further report by John Block, the author concludes that visually impaired elementary age print readers as a total group, perform equally well on standard and large print. This reference is from 'Reading Performance of Visually Impaired Print Readers using Standard Print, Large Print and Magnification', *Diss Abstracts International*, 1972, vol. 33A.

7.4 Typographic Factors to be Tested and Settings of Text.

Typefaces

The typefaces selected for this study were Janson Text and Optima, which are representative examples of the two main categories of type design used for reading matter. Both typefaces were selected as a result of the preliminary test.

Type size

12 point on 15 point line Increment

15 point on 18 point line Increment

18 point on 22 point line Increment, 2 point letter spacing.

Type size was chosen based on logic analysis of the difficulties incurred when reading with RP. Many people with low vision read text at a size very close to their visual threshold limit. It is important to establish that the object of the test was not to determine absolute sizes for legibility but to establish the relative importance of size. Three progressive type sizes were chosen; 12 point-an acceptable size for normal sighted readers, 15 point-chosen as an intermediate size and 18 point-as a commonly used size in publications for low vision reading. As kerning was not a macro consideration in this research, it was decided that the default kerning on the application programme Quark Xpress, was adequate for the purpose of testing. Letter spacing of 2 point was introduced at 18 point in both Optima and Janson Text to aid legibility. [7]

7. As the size of certain typefaces increases, there is a need to increase space between letters to avoid the risk of overly tight letter spacing and to improve greater reading efficiency.

Layout

1 column grid

2 column grid

A one column grid was chosen as being representative of the setting found in novels. The smaller widths of a two column grid can be found in magazines and articles and was chosen to test ease of reading and reduced head movement.

Colour

1. Yellow text on a black background
2. Black text on yellow background
3. White text on a black background
4. Black text on a white background
5. Blue text on a yellow background
6. Yellow text on a blue background [8]

8. Colour considerations were chosen as previously discussed in Part 6.17.

7.5 Basis of the Test

- A series of timed tests was individually administered. It was decided not to administer the test by a postal survey in order to have direct control over the testing process.

- The relativity of testing results was within-individual variability in the rate of searching for specific words.

- The duration of the test should not last longer than 30 minutes, in order to avoid subject fatigue.

- A laboratory-type controlled environment was not possible due to the various nationwide locations of the subjects. Furthermore it is argued that the circumstance of a laboratory situation provides a false setting and does not truly depict a 'real-life' situation or evoke natural responses from subjects. [9] Shaw drew attention to the danger of comparing the results of laboratory experiments to practical situation and the interaction of many stimuli under natural conditions which are deliberately excluded from laboratory research. [10]

9. Foster, J., *Legibility Research 1972-1978, A Summary*, p. 10.

10. Shaw, A., *Print for Partial Sight*, pp. 34-35.

• Each person was interviewed and tested in their normal reading environment. The test was administered under lighting conditions, judged to be good by the researcher; either in day light or artificial lighting, in relation to the needs of the individual. The specific effects of illumination were not investigated in this study. Light adaptation plays an important role in the reading process of a person with RP vision. It was evident from interviewing subjects that the effect of illumination was specific to each individual and therefore the use of a standard measure of illumination would be diverging from the requirement to keep the testing situation as comparable to a 'real life' situation as possible.

7.6 The Choice of Scanning Method

The scanning method is an important approach for assessing legibility; when people are not concerned with reading every word, the criterion for legibility being the rate of locating particular target words. There are many advantages to using the scanning method 'particularly when thorough reading is held back by a sight impairment, since words have to be both seen in skimming and reading.' [11] Additional advantages for administrating a test of this kind are outlined as follows;

• Scanning is very reliable and it gives dependable results with fewer people than other measures of legibility. The rate of skimming is sensitive to the smallest changes, hence it is the best method to use for testing sight impaired readers. [12]

11. Poulton, E.C., 'Skimming News items Printed in 8pt and 9pt Letters', *Ergonomics*, vol. 10, No. 6, p. 713.

12. Poulton, E.C., 'The Measure of Legibility', *Printing Technology*, vol. 12, p. 73.

• There is little interference from experimental biases as there is with other methods of testing and scanning also eliminates the need for control over word content. It is impossible to have control over the reading ability of each subject or to standardise visual acuity, when conducting research on such a diverse visual impairment as RP. Considering the subject is required to search for single words only, scanning eliminates any reference to inherent reading ability, as this method is based on using contextual clues to find words and there is no question to whether an answer is right or wrong as there is with comprehension studies.

7.7 Selection Of Participants

Research was conducted with a cohort study of 22 subjects with RP vision of various backgrounds and a control group of 7 subjects with normal vision. The control group was used to provide an indicative reference to the performance from normal sighted subjects and to highlight the problems of reading disability. The target group of RP sighted individuals included 11 males and 16 females of various age groups subdivided into groups of under 18 years old, 18-30, 31-45, 45-60 and over 60 years old. The youngest of the 29 subjects was 8 years old and the oldest was 61 years old. The number of participants correspond to those used in recent tests by Roelofs, Ton (1997) whose experiments were conducted with a small number of observers. [13] 'It would have been nicer to use larger populations but the duration of the experiments made this practically impossible. For the chapter about low vision, an additional argument for using small populations was the difficulty of recruiting these observers.'

13. Roelofs, T., *Image Enhancement for Low Vision*, p. 8.

To test the visual acuity of individual disorders, Roelofs used a group of 14 cataract subjects, a group of 14 age related macular degeneration patients and a group of 4 post-operatic cataractous observers. [14] In this study, the target group of subjects were recruited from responses to articles in the national RP Newsletter, members of RP Ireland-Fighting Blindness, students from St. Josephs School for the Blind and Partially Sighted and contacts with the National Council for the Blind. The members of this group were selected on a voluntary basis and therefore not fully representative of a statistically derived sample, however the resulting data should have relevance to any group of RP readers with similar visual acuity. With an estimated population of 1,000 RP sighted people in Ireland, with varying degrees of sight for reading, a sample size of 20 out of 1,000 was considered a reasonable group size to test, in the context of the Irish population. [15] While a larger population sample would have increased the representational accuracy of the results, it is shown to be sufficiently large to allow discrimination between the effects of the primary test variables.

The vision threshold for RP subjects was standardised by selecting a viable contact group on the basis that although they exhibited some apparent loss of peripheral vision, they retained an ability to read under normal circumstances. [16] It was decided at an early stage in planning this present research that defective vision that extends beyond this would not be investigated. This criterion restricted participants to an early phase or a stabilised state of the condition.

14. op. cit., p. 57.

15. Information was not statistically available on the number of people with RP who still maintained sufficient vision for reading print

16. Persons who good measurable vision for reading print and whose needs do not require optical reading aids such as closed-circuit television and reading machines.

Despite this selection basis, some of those tested were subsequently eliminated because of an inability to read the largest print size due to an excessive level of visual impairment. It was emphasised when requesting volunteers, and continually throughout testing, that this research was neither a test of the intelligence or visual acuity of the partially sighted reader. It was further stressed that the research was solely a method of testing various typographic combinations as a means of making valid conclusions to improve legibility for readers whose vision is impaired by RP. Three factors limit the homogeneity of the test group:

- The natural reading level of individuals.
- The extent of individual visual impairment.
- Variability in the test environment.

7.8 Test Methodology

- A series of timed tests was individually administered. Subjects were instructed to scan read each text until they were told to finish by the researcher. They were informed that they were being timed, using a stop watch, for 60 seconds per test. A multiple word-identification test procedure was adopted using single page prose excerpts which required a basic level of reader comprehension ability which was suitable for the test subjects. Reading scores, any skipped target words and data collected in the course of each interview were noted and used as the basis of statistical analysis. The measure of reading performance attained by each subject was based on the maximum amount of words located per minute.

7.9 Visual Appearance

• Twelve semi-technical regional geographical texts were derived from previous legibility tests by Reynolds et al. [17] The one column grid texts occupied approximately 40 lines on an A3 page and the two column grid occupied approximately 30 lines per column on an A3 page. The pages were divided into two sections of twelve target words per section, positioned adjacent to the text passages. Each one column text was divided mid-way by a horizontal line that indicated the location of the first 12 words in the text, the second section indicating the location of the latter target words. The target words were set in Helvetica regular and the size corresponded with the text size of the sheet i.e. 18 point Helvetica target words with 18 point Optima prose. The 24 target words were selected randomly and positioned approximately three lines apart in the text. The position of the target words varied slightly throughout the 12 sheets, to avoid over familiarity with the location of the target words. The test sheets contained line lengths as follows;

1 column 12pt approximately 100mm long

1 column 15pt approximately 120mm long

1 column 18pt approximately 150mm long

2 column 12pt approximately 65mm long

2 column 15pt approximately 80mm long

2 column 18pt approximately 100mm long

17. The test material was adopted from *The Effects of Different Kinds and Intensities of Background 'Noise' on the Legibility of Printed Text and Numerals*, Readability of Print Research Unit, RCA, 197, with kind permission from the author, Linda Reynolds, et al.

Two typefaces and three font sizes were utilised. Tests were performed in the order of Janson Text, 12 point, 15 point, and 18 point, one column, followed by Janson Text, 12 point, 15 point, and 18 point, two column, and repeated in the same combination for Optima. The 12 texts were ranged left and typeset on a Macintosh Computer using the software Quark Xpress. [18] Test passages were printed in black ink on a single sheet of white matt paper. The effects of colour contrast was partially and separately examined.

7.10 Reading Distance

Reading distance was not controlled although it was requested that each subject read the 12 texts at the same distance throughout the test and in a position that was most comfortable to the individual.

7.11 Testing Instructions

A list of testing instructions adapted from testing material by Reynolds *et al.* was provided for each subject and they were requested to read and understand these instructions before proceeding with the test. [19] Oral instructions were given if the subject had difficulty understanding the written instructions. [20]

18. See Appendix L for an example of the test material. The tests were administered on A3 sheets as opposed to A4, as shown.

19. Reynolds, L., *The Effects of Different Kinds and Intensities of Background 'Noise' on the Legibility of Printed Texts and Numerals*, Readability of Print Research Unit, RCA, 1977

20. The written instructions are provided in Appendix I.

A questionnaire was completed by each subject in order to obtain additional background information to the testing and to compare the differences in the subjective and objective responses of each subject. Personal data was collected for each subject to identify sub-groups of readers and to investigate if the data had any relevance of their scores. Subject's opinions were also taken into consideration as a reference to personal difficulties incurred when reading with a vision deficiency. [21]

21. A comprehensive list of individual scores and information on each subject is available in Appendix K.

7.12 Data Analysis and Principle Findings based on Results

It was noted from the results that visual preference does not provide an accurate indicator of legibility. Performance was not always consistent with the subjective responses of individual subjects regarding the optimum type size and typeface as a comfortable threshold for legibility. Analysis of results highlighted a large discrepancy between choice preference and performance ratings.

Percentages decreased from a 25% choice preference to 15% performance at 12 point type size, from 40% to 25% at 15 point and increased from 35% to 60% at 18 point.

		Preference				
		12pt	15pt	18pt		
	12pt	1	2	0	= 3	15%
Performance	15pt	2	2	1	= 5	25%
	18pt	2	4	6	=12	60%
		5	8	7		

Total N=20

Figure 4. Type Size Preference to Performance

Choice responses showed that 52.63% of all readers with RP preferred Janson Text, to 47.36% who preferred Optima. Contrary to this response, Optima proved to be significantly more effective than Janson Text in terms of reading performance by a ratio of 73.68% : 26.31%

		Preference			
		Optima	Janson Text		
Performance	Optima	7	7	= 14	73.68%
	Janson Text	2	3	= 5	26.31%
		9	10		

Total N=19 (1 subject had no preference)

Figure 5. Typeface Preference to Performance

Results suggest that age does not influence speed of reading, i.e. the amount of target words found in 60 seconds, as there was no significant differences in target word identification and in the various age groups. Readers with a visual impairment can have a misguided perception. This leads to tracking problems which causes loss of position on a page of text. The reader is forced to return to the start of a line or, in the case of this test, to the previous target word to regain their position on the page. The erratic reading behaviour of sight impaired readers was noted in the higher proportion of regressions recorded and in the fact that over 50% of subjects overlooked target words when scanning.

Test results show a 40% : 60% preference ratio, for a two column grid over a single column of text although performance rated a 70% : 30% in favour of a one column grid.

	Preference				
	1	2			
Performance	1	7	7	= 14	70%
	2	1	5	= 6	30%
	8	12			
Total N=20					

Figure 6. Column Preference to Performance

Literature on the condition RP and analysis of the information obtained from interviewing RP subjects, claim that the primary aspect of legibility is influenced by contrast between typeface and background. Contrary to the results of earlier studies, as outlined in part 4.6, RP sighted readers preferred and selected dark characters against a light background. Black type on a yellow background was the preferred colour combination for 50% of subjects, followed by 35% who preferred black type on a white background. Reversed-out type in printed material was not a popular option for RP subjects although those who frequently used a computer, commented that they used reversed-out type for on-screen reading. 10% of all subjects preferred white on black and only 5% preferred yellow on black.

Black text on White;	7
White text on Black;	2
Blue text on Yellow;	0
Yellow text on Blue;	0
Black text on Yellow;	10
Yellow text on Black;	1
Total N=20	

Figure 7. Preferred Colour Combination

Normal reading distance generally lies between 12 and 14 inches. 14.8% subjects in this research had a reading distance of less than 8 inches. One might assume that the more avid reader would score higher than an infrequent reader. However research does not produce evidence to confirm this. The 35% of subjects who reported relatively infrequent reading habits performed almost as well as those who read frequently.

Frequent	11
Average	2
Newspapers and magazines only	4
Rarely	3
Total N=20	

Figure 8. Reading Interest of RP Subjects

Subjects	Preferences
S1	Black on Yellow
S2	Black on White
S3	Black on White
S4	Black on Yellow
S5	Black on White
S6	Black on Yellow
S7	Black on Yellow
S8	Black on Yellow
S9	Yellow on Blue
S10	White on Black
S11	Black on Yellow
S12	Black on White
S13	Black on White
S14	Black on Yellow
S15	Black on Yellow
S16	Black on Yellow
S17	White on Black
S18	Black on Yellow
S19	Black on White
S20	Black on White
SA	Blue on Yellow
SB	Black on White
SC	Black on White
SD	Black on White
SE	Black on White
SF	Black on White
SG	Black on White

Figure 9. Individual Preferences for Colour Combinations

The following diagram illustrates the performance differences between Janson Text and Optima in the three type sizes. Prince claimed that the differences in legibility between styles of fonts diminished as the size of type increased. His theory has been proven in the statistics derived from this test. 25% of subjects scored a difference of more than three target words at 18 point between Optima and Janson Text, whereas there was a 65% difference at 12 point and 60% at 15 point.

	Janson	Optima	Janson	Optima	Janson	Optima
	12pt		15pt		18pt	
S1	18	23*	18	23*	24	21
S2	0	0	2	2	4	3
S3	34	25*	33	5*	40	32*
S4	22	25	20	20	24	25
S5	15	24*	18	28*	26	24
S6	14	23*	11	22*	23	24
S7	23	19*	14	32*	17	22*
S8	19	17	19	23*	22	20
S9	32	32	34	38*	36	34
S10	25	26	23	36*	30	34
S11	6	6	6	6	10	9
S12	13	13	11	19*	15	17
S13	29	36*	26	27	34	29*
S14	31	35*	27	39*	39	37
S15	31	32	33	33	34	36
S16	33	37*	30	33	31	37*
S17	24	28*	35	27*	20	21
S18	26	37*	29	37*	31	30
S19	30	43*	35	44*	24	37*
S20	9	5*	9	6	7	8

* = Deviation of more than 3 target words

Total N=20

Figure 10. Performance Differences between Janson Text and Optima in 3 Type Sizes

The consistent results of the control group of readers highlights the contrast in the varied results from RP sighted readers. The performance difference in typeface was too slight for subjects with normal vision to observe a measurable difference, confirming previous research that the option of a sanserif or a serif typeface for normal sighed readers relates to personal choice and one type style is not significantly more legible than the other. A lack of a conclusive outcome may further suggest that a scanning test of this nature is an unsuitable measure of legibility for 'normal sighted' readers.

S	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
A	6	19	15	14	10	15	19	19	21	14	19	12
B	23	21	23	22	13	22	23	22	22	19	21	21
C	24	24	24	24	24	24	24	24	24	24	24	24
D	24	24	24	24	24	22	24	22	22	23	24	24
E	24	24	24	24	24	24	24	24	24	22	24	24
F	12	20	24	14	18	23	22	23	24	24	23	23
G	23	23	22	24	22	24	24	23	23	23	24	24

Figure 11. Control Group Subject Scores

7.13 Preliminary Data Adjustment Procedures

It is clear from an examination of the test scores, as shown in the **Original Tests Results by Subject and Test (pg 114)** table, that there is a significant variability in mean performance level between individuals as a result of sight impairment, different environmental reading conditions, variability in reading ability, some of which were counteracted by the scanning method of testing. By eliminating extreme outlyers prior to to final group selection, the impact of variability in reading ability and in the degree of visual impairment has been restricted. However it is noted that the performance data are relative for each individual and, on this basis, data are normalised with respect to individual subject averages. This adjustment mechanism counteracts the principal non-homogeneity factors and presents a more unified set of data to analyse. Further to clarify data representation and analysis, the normalised subject data are retabulated as zero-mean scores as shown in the **Zero-Mean Adjusted Normalised Scores (pg 115)** table. In both tables, and in subsequent references, tests are designated by a composite code, typeface (1 or 2), single or double column layout (S or D) and font size (12, 15, or 18)

7.14 Hypothesis Formulation and Testing

The function of the tests is to allow conclusions to be drawn regarding the impact and effectiveness of typeface, type size and layout on legibility performance. These primary variables are essentially qualitative and independent. Within the context of the tests, individuals may identify words on a character by character basis, or be able to recognise a word pattern or discriminate over a group of words.

Clearly, scanning and the use of peripheral vision become more significant over this progression. At smaller type sizes, scanning potential is increased and word patterns are more easily recognised. Individuals with relatively poor eyesight may however be disadvantaged by reduced character size. Conversely, at a large font size it is difficult to benefit from an ability to scan and there is likely to be a more uniform level of performance on the basis of an isolated word identification task. Word search techniques may also have an impact on performance. Efficient searchers will not seek to identify each character in every word but they will look for key matching lead sequences. The adopted data standardisation by relative normalisation approach largely counteracts variations in search technique. Analytically the use of multivariate or factor analysis is of questionable benefit and validity in the context of this problem approach and the relatively small sample population. On the basis of independence, a univariate approach is considered to be preferable in the context of providing a viable basis for hypothesis testing.

Distribution analysis and correlation analysis provide suitable bases for establishing consistency in the data and for the hypothesis testing. From an examination of the **Correlation Values by Subject table (pg 116)** it can clearly be seen that there is significant positive correlation between subjective test scores. All responses are inter-linked at a correlation value of 0.39. This indicates that there is broad similarity in the reaction of each individual to the group of tests and that there is no evidence of significant outlyer behaviour in the sample group. The **Summary Statistics for Test Results by Test (pg 104)** table and the **Test Result Distribution (App. N, pg 186)** plot clearly indicate Gaussian similarities in the individual test plots.

It is interesting to note from the Kurtosis values that, with the exception of the 15pt distributions, the distributions are more peaked and have longer tails than corresponding Gaussian distributions which may give rise to pessimistic confidence level predictions. Similarly it may be seen that the skewness changes from negative to positive with increasing point size.

The contrasts and similarities which are present in the reaction of the target group as a whole to differing tests may be seen, perhaps with some difficulty of interpretation, in the table **Correlation Values by Test (pg 117).** It is useful to relate this information to that provided in the **Mean & Standard Deviation by Test (App. N, pg 185)** plot. The correlation values indicate the extent of the similarity (either positive or negative) between the individual test results pattern. It should be remembered that the range (0^+, 1) indicates positive similarity whereas the range (0^-, -1) indicates negative similarity; values in the vicinity of 0 indicate dissimilarity. It is to be expected that good performance tests should exhibit dissimilar or negative similarity responses in comparison with poor performance tests.

In general it may be asserted that high mean scores are indicative of good legibility performance and low standard deviations are indicative of consensus. The **Mean & Standard Deviation by Test (App. N, pg 185)** plot provides a useful means of depicting relative performance. There is however a need for caution in interpreting isolated results in view of the variability represented in the confidence limits as depicted in the **Mean Values Ranges by Test (App. N, pg 185)** plot.

The relative positioning, shape and parameters of the test distribution functions is a good indicator of difference in performance. T-Tests may be used to compare distributions and to establish a likelihood of separateness or similarity.

7.15 The Impact of Typeface

The **Mean & Standard Deviation by Test (App. N, pg 181)** plot clearly indicates that the performance of Optima (typeface 2) is, in general, superior to that of Janson Text (typeface 1) but that the performance differential is nullified when the point size is large.

The previous conclusion is reinforced by the form of the distributions shown in the **Test Results Distribution (App. N, pg 182)** plots. Optima outperforms Janson Text except in the case of 18pt where there is indifference.

The **t-Test Distribution Analysis of Typeface 1 and Typeface 2 Tests (pg 108)** table may be interpreted as indicating that, at a 95% confidence level, there is at least a 95% likelihood that the responses shown in the **Normalised Frequency Distribution by Typeface (App. N, pg 184)** plot originate from two populations with different mean values.

The **Correlation Values By Test (pg 113)** table is complex and does not provide a suitable basis for typeface comparison in isolation.

7.16 The Impact of Point Size

The **Mean & Standard Deviation By Test (App. N, pg 181)** plot clearly indicates that the use of small typefaces, 12pt, produces relatively poor results. Large typefaces, 18pt, tend to result in good legibility but there is significant variability in subjective performance. The use of an intermediate size 15pt appears to result in good legibility and consistent performance over the sample group. On this basis, 15pt may be considered to be the preferred choice.

The **Normalised Frequency Distributions by Size (App. N, pg 183)** plots indicate that while 12pt is legible for some, there is a significant grouping for which it is substantially illegible. In the case of 18pt, the performance is good. With 15pt, the overall performance may appear to be slightly inferior to that of 18pt but much of this may be attributed to the significantly negative impact of the typeface 1 performance. In this light it would appear that the distributions may be considered to support the contention that Optima 15pt is the preferred combination.

The **Statistical Analysis of Size (pg 115)** table examines the similarity between different size pairings. The indications are that there is a substantial difference between performance results.

Further examinations of the values shown in the **Correlation Values by Test (pg 113)** table shows that all 12pt responses are significantly positively correlated, associated with their clustered positions in the **Mean Score & Standard Deviation by Test (App. N, pg 181)** plot. The inference is that the size factor is having a major negative impact on performance.

A further cluster which exhibits even greater positive correlation is formed from the large 18pt typeface results. The 15pt results are more complex to interpret. The two Optima (typeface 2) distributions are positively correlated but are substantially dissimilar to, or negatively correlated with the Janson Text (typeface 1) distributions. It is interesting to note that the best performing test (2S15) has a negative correlation with or is dissimilar to all other tests with the exception of 2D12 and 2D15. This is clearly indicative of the superiority of Optima and of 15pt but may also lend support to the hypothesis that large typefaces impose uniformity in reading technique.

7.17 The Impact of Layout

From the **Mean Score and Standard Deviation by Test (App. N, pg 181)** plot it can be seen that, at smaller type sizes, legibility is improved by moving from a single to a double column layout. The effect of layout appears to be relatively weak and may be masked by the other factors. There is some evidence to suggest that double column layout produces a greater uniformity in performance.

The **Normalised Frequency Distribution by Layout (App. N, pg 183)** plots would seem to suggest that overall there is little difference in performance as a result of layout variation. There is no strong statistical evidence in general to suggest that the impact of layout has any difference in effectiveness. However, it seems reasonable to suggest that in practice, the application of a 2 column grid layout leads to an increase in efficiency and is less onerous than a 1 column grid. The long lines of text associated with a 1 column grid increases the number of regressions per sentence and adds to the amount of head movement needed to aid scanning.

Personal data was collected from each subject in order to accumulate general information regarding the RP population in Ireland. In terms of further investigating correlations on the basis of sex, age and the particular nature of RP deficiency, the researcher would require an extensive sample to obtain reasonable significance of results and therefore it was decided to exclude these elements from the data analysis. Individual subject data is summarised in the following tables.

Sex			**Use of Optical Aids**		
Male	9	45%	Glasses all the time	9	45%
Female	11	55%	Glasses for reading only	4	20%
Total N =20			Magnifier	1	5%
			No Optical Aids	6	30%
			Total N =20		
RP Diagnosis			**Age Bracket**		
Dominant	5	25%	Below 18	2	10%
Recessive	9	45%	18-30	3	15%
X-Linked	2	10%	31-45	6	30%
Sporadic	2	10%	46-60	6	30%
Don't know	2	10%	Over 60	3	15%
Total N =20			Total N =20		

Figure 12. Personal Data on RP Subjects

Figure 13. Original Test Results by Subject and Test

S	1S12	1S15	1S18	1D12	1D15	1D18	2S12	2S15	2S18	2D12	2D15	2D18	Mean	SD	95% CL
S1	6	11	13	12	7	11	13	12	11	10	11	10	10.583	2.151	1.217
S2	0	1	2	0	1	2	0	1	2	0	1	1	0.917	0.793	0.449
S3	16	19	21	18	14	19	10	13	16	15	12	16	15.570	3.194	1.807
S4	12	15	13	10	5	11	17	10	13	8	10	12	11.333	3.143	1.778
S5	9	9	13	3	9	13	14	15	12	10	13	12	11.000	3.247	1.837
S6	5	5	13	9	6	10	11	10	12	12	12	12	9.570	2.896	1.638
S7	11	12	7	12	2	10	9	14	12	10	8	10	9.750	3.108	1.758
S8	8	9	10	11	10	12	6	15	8	11	8	12	10.000	2.412	1.365
S9	15	17	17	17	17	19	19	20	17	13	18	17	17.167	1.850	1.047
S10	16	12	7	9	11	13	12	20	18	14	16	16	12.833	3.810	2.156
S11	3	2	4	3	4	6	5	3	6	1	3	3	3.583	1.505	0.852
S12	6	4	6	7	7	9	5	9	10	8	10	7	7.333	1.923	1.088
S13	15	17	18	14	9	16	18	18	15	18	9	14	15.083	3.232	1.829
S14	15	14	19	16	13	20	17	20	18	18	19	19	17.333	2.348	1.329
S15	15	17	17	16	16	17	17	16	19	15	17	17	16.583	1.084	0.613
S16	18	14	11	15	16	20	18	17	18	19	16	19	16.750	2.527	1.430
S17	11	11	9	13	16	11	13	15	11	15	12	10	12.250	2.179	1.233
S18	8	18	18	18	11	13	20	19	13	17	18	17	15.833	3.689	2.087
S19	17	17	13	13	18	11	19	21	22	24	23	15	17.750	4.224	2.390
S20	4	4	4	5	5	3	1	3	2	4	3	6	3.667	1.371	0.776
Mean	10.500	11.400	11.750	11.050	9.850	12.300	12.200	13.550	12.250	12.100	11.950	12.250	**Global Mean**	11.763	
SD	5.316	5.679	5.543	5.276	5.204	5.162	6.187	5.995	5.359	6.052	5.772	5.087	**Global SD**	5.513	
95%CL	2.330	2.489	2.429	2.312	2.281	2.262	2.711	2.628	2.349	2.652	2.530	2.230	**Global CL**	0.697	

	1S12	1S15	1S18	1D12	1D15	1D18	2S12	2S15	2S18	2D12	2D15	2D18	S D	95% CL
s1nzm	-0.433	0.039	0.228	0.134	-0.339	0.039	0.228	0.134	0.039	-0.055	0.039	-0.055	0.203	0.115
s2nzm	-1.000	0.091	1.181	-1.000	0.091	1.181	-1.000	0.091	1.181	-1.000	0.091	0.091	0.865	0.489
s3nzm	0.016	0.206	0.333	0.143	-0.111	0.206	-0.365	-0.175	0.016	-0.048	-0.238	0.016	0.203	0.115
s4nzm	0.059	0.324	0.147	-0.118	-0.559	-0.029	0.500	-0.188	0.147	-0.294	-0.118	0.059	0.277	0.157
s5nzm	-0.182	-0.182	0.182	-0.727	-0.182	0.182	0.273	0.364	0.091	-0.091	0.182	0.091	0.295	0.167
s6nzm	-0.487	-0.487	0.333	-0.077	-0.385	0.026	0.128	0.026	0.231	0.231	0.231	1.231	0.297	0.168
s7nzm	0.128	0.231	-0.282	0.231	-0.795	0.026	-0.077	0.436	0.231	0.026	-0.179	0.026	0.319	0.180
s8nzm	-0.200	-0.100	0.000	0.100	0.000	0.200	-0.400	0.500	-0.200	0.100	-0.200	0.100	0.241	0.136
s9nzm	-0.126	-0.010	-0.010	-0.010	-0.010	0.107	0.107	0.165	-0.010	0.243	0.049	-0.010	0.099	0.056
s10nzm	0.247	-0.065	0.465	-0.299	-0.143	0.013	-0.065	0.558	-0.377	0.091	0.247	0.247	0.287	0.163
s11nzm	-0.163	-0.442	0.116	-0.163	0.116	0.675	0.395	-0.163	0.675	-0.721	-0.163	-0163	0.420	0.238
s12nzm	-0.182	-0.455	-0.182	-0.045	-0.045	0.227	-0.318	0.227	0.364	0.091	0.364	-0.045	0.262	0.148
s13nzm	-0.006	0.127	0.193	-0.072	-0.403	0.061	0.193	0.193	-0.006	0.193	-0.403	-0.072	0.214	0.121
s14nzm	-0.135	-0.192	0.096	-0.007	-0.025	0.154	-0.019	0.154	0.038	0.038	0.096	0.096	0.111	0.063
s15nzm	-0.095	0.025	0.025	-0.035	-0.035	0.025	0.025	-0.035	0.146	-0.905	0.025	0.025	0.065	0.037
s16nzm	0.075	-0.164	-0.343	-0.104	-0.045	0.194	0.075	0.015	0.075	0.134	-0.045	0.134	0.151	0.085
s17nzm	-0.102	-0.102	-0.265	0.061	0.306	-0.182	0.061	0.224	-0.102	0.224	-0.020	-0.184	0.178	0.101
s18nzm	-0.495	0.137	0.137	0.137	-0.305	-0.179	0.263	0.200	-0.179	0.074	0.137	0.074	0.233	0.132
s19nzm	-0.042	-0.042	-0.268	-0.268	0.014	-0.380	0.070	0.183	0.239	0.352	0.296	-0.155	0.238	0.13
s20nzm	0.091	0.091	0.091	0.364	0.364	-0.182	-0.727	-0.182	-0.455	0.091	-0.182	0.636	0.374	0.212
Mean	0.152	-0.049	0.109	-0.091	- 0.125	0.122	-0.033	0.140	0.107	-0.021	0.010	0.062		
SD	0.280	0.226	0.337	0.312	0.278	0.326	0.369	0.216	0.356	0.325	0.202	0.182	Global SD 0.300	
95% CL	0.123	0.099	0.148	0.137	0.122	0.143	0.162	0.095	0.156	0.142	0.088	0.080	Global CL 0.038	

	T.Face 1	T.Face 2	12 pt	15 pt	18pt	S. Col	D. Col
Mean	-0.031	0.044	-0.074	-0.006	0.100	0.031	-0.017
SD	0.0309	0.287	0.321	0.248	0.303	0.311986	0.280
95% CL	0.055	0.051	0.070	0.054	0.066	0.056	0.050

Figure 14. Zero-Mean Adjusted Scores

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
S1	1																			
S2	0.244	1																		
S3	0.062	0.457	1																	
S4	0.492	0.049	0.064	1																
S5	0.312	0.459	-.342	0.285	1															
S6	0.624	0.309	-.106	0.110	0.493	1														
S7	0.324	-0.12	0.112	0.428	-.009	0.044	1													
S8	0.088	0.190	0.247	-.468	0.058	0.104	0.267	1												
S9	0.421	-.100	-.349	-.177	0.390	0.466	0.148	0.383	1											
S10	0.065	0.081	-.028	-.021	0.543	0.212	0.056	0.419	0.173	1										
S11	0.193	0.578	0.015	0.262	0.354	0.203	-.141	-.225	-.166	-.326	1									
S12	0.037	0.377	-.208	-.457	0.291	0.490	0.106	0.313	0.330	0.024	0.273	1								
S13	0.477	-.032	0.248	0.552	0.251	0.187	0.563	0.175	0.382	0.233	-.048	-.327	1							
S14	0.367	0.516	-.116	-.225	0.672	0.755	-.049	0.509	0.514	0.452	0.323	0.695	0.029	1						
S15	0.463	0.696	0.099	0.471	0.361	0.398	0.075	-.279	-.167	-.341	0.665	0.249	-.041	0.235	1					
S16	-.305	-.193	-.414	-.102	0.199	0.078	0.224	0.104	0.344	-.170	0.186	0.393	0.004	0.243	-.073	1				
S17	-.208	-.460	-.578	-.624	-.141	-.206	-.192	0.242	0.524	-.134	-.270	0.174	-.185	-.008	-.490	0.226	1			
S18	0.850	-.098	-.166	0.342	0.220	0.506	0.250	0.143-	0.507	0.208	-.260	-.120	0.352	0.229	0.161	-.308	0.028	1		
S19	-.093	-.251	-.679	-.165	0.265	0.180	0.071	.205	0.412	0.020	-.304	0.370	-.106	0.043	-.024	0.223	0.491	0.119	1	
S20	-.421	-.112	0.436	-.499	-.552	-.252	-.214	0.440	-.334	0.113	-.514	-.196	-.321	-.155	-.409	-.185	-.030	-.173	-.377	1

Figure 15. Correlation Values by Subject

Figure 16. Correlation Values by Test

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
TI	1											
T2	0.158	1										
T3	-.612	0.143	1									
T4	0.468	0.165	-.586	1								
T5	-.084	-.330	0.023	-.101	1							
T6	-.565	-.193	0.635	-.613	0.178	1						
T7	0.278	-.105	-.411	0.136	-.442	-.406	1					
T8	0.070	-.054	-.104	-.154	-.240	-.130	-.003	1				
T9	-.610	-.205	0.412	-.632	-.022	0.776	-.177	-.231	1			
T10	0.503	-.054	-.652	0.553	-.086	-.849	0.241	0.320	-.746	1		
T11	-.290	-.478	0.048	-.389	0.107	-.085	0.028	0.283	0.147	0.133	1	
T12	0.101	0.085	0.233	0.150	0.144	-.101	-.472	-.064	-.417	0.082	-.052	1

Figure 17. Summary Statistics for Test Results by Test

	1S12	1S15	1S18	1D12	1D15	1D18	2S12	2S15	2S18	2D12	2D15	2D18
Mean	-0.152	-0.049	0.109	-0.091	-0.125	0.122	-0.0327	0.140	0.107	-0.021	0.010	0.062
Standard Error	0.063	0.051	0.075	0.070	0.062	0.073	0.0826	0.048	0.080	0.073	0.045	0.041
Median	-0.114	-0.026	0.106	-0.059	-0.045	0.050	0.0655	0.160	0.057	0.083	0.032	0.043
Mode	-0.182	0.091	0.333	-0.077	-0.045	0.026	0.000	0.000	0.231	0.091	0.000	0.091
Standard Deviation	0.280	0.226	0.337	0.312	0.278	0.326	0.369	0.216	0.356	0.325	0.202	0.182
Sample Variance	0.079	0.051	0.114	0.097	0.078	0.106	0.137	0.047	0.127	0.105	0.041	0.033
Kurtosis	3.382	-0.167	4.575	3.399	0.661	5.629	1.438	-0.486	3.704	4.254	-0.582	4.325
Skewness	-1.543	-0.564	1.549	-1.628	-0.567	1.952	-1.190	0.234	1.408	-2.017	-0.121	1.555
Range	1.247	0.811	1.524	1.364	1.159	1.561	1.500	0.740	1.636	1.352	0.767	0.820
Minimum	-1.000	-0.487	-0.343	-1.000	-0.795	-0.380	-1.000	-0.182	-0.455	-1.000	-0.403	-0.184
Maximum	0.247	0.324	1.181	0.364	0.364	1.181	0.500	0.558	1.181	0.352	0.364	0.636
Sum	-3.032	-0.970	2.177	-1.825	-2.491	2.444	-0.653	2.797	2.144	-0.416	0.209	1.242
Count	20	20	20	20	20	20	20	20	20	20	20	20
C. L. 95%	0.131	0.106	0.158	0.146	0.130	0.153	0.173	0.101	0.167	0.152	0.094	0.085

	12pt	15pt	15pt	18pt	18pt	12pt
Mean	-0.0741		-0.0057	0.10009	0.10009	-0.0741
Variance	0.1032980	-0.0057	0.06143	0.09194	0.09194	0.10329
Observations	0.06825	0.06143	80	80	80	80
Pearson Correlation	0	80	0.01483		-0.3497	
Hypothesised Mean Difference			0		0	
df	79		79		79	
t Stat	-1.5594		-2.4335		3.03536	
P(T<=t) one-tail	0.06145		0.00861		0.00163	
t Critical one-tail	1.66437		1.66437		1.66437	
P(T<=t) two-tail	0.12289		0.01721		0.00325	
t Critical two tail	1.99045		0.99045		1.99045	

Figure 18. Statistical Analysis of Size t-Test: Paired Two Sample for Means

Range	**Typeface**		**Point Size**			**Page Layout**		**Overall**
	Type1	**Type2**	**12pt**	**15pt**	**18pt**	**SC**	**DC**	
-1.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-1.0	0.017	0.017	0.050	0.000	0.000	0.017	0.017	0.017
-0.8	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000
-0.6	0.017	0.017	0.038	0.013	0.000	0.008	0.025	0.017
-0.4	0.067	0.025	0.050	0.075	0.013	0.067	0.025	0.046
-0.2	0.092	0.058	0.075	0.063	0.088	0.075	0.075	0.075
0.0	0.350	0.242	0.313	0.350	0.225	0.267	0.325	0.296
0.2	0.317	0.408	0.325	0.313	0.450	0.350	0.375	0.363
0.4	0.108	0.175	0.138	0.150	0.138	0.150	0.133	0.142
0.6	0.008	0.033	0.013	0.038	0.013	0.042	0.000	0.021
0.8	0.008	0.017	0.000	0.000	0.038	0.008	.017	0.012
1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	0.017	0.008	0.000	0.000	0.038	0.017	0.008	0.012

Figure 19. Normalised Distribution

Figure 20. Performance Similarities between Two Typefaces of Identical Point Size

t-Test: Paired Two Sample for Means

	1S12	**2S12**	**1D12**	**2D12**	1S15	2S15	1D15	2D15	1S18	2S18	1D18	2D18
Mean	-0.152	-0.033	-0.091	-0.021	-0.049	0.14	-0.125	0.01	0.109	0.107	0.122	0.062
Variance	0.079	0.137	0.097	0.105	0.051	0.047	0.078	0.041	0.114	0.127	0.106	0.033
Observations	20	20	20	20	20	20	20	20	20	20	20	20
Pearson Correlation	0.278		0.553		-0.054		0.107		0.412		-0.101	
Hypothesized Mean Diff.	0		0		0		0		0		0	
df	19		19		19		19		19		19	
t Stat	-1.34		-1.046		-2.622		-1.852		0.02		0.691	
P(T<-t) one-tail	0.098		0.154		0.008		0.04		0.492		0.249	
t Critical one-tail	1.729		1.729		1.729		1.729		1.729		1.729	
P(T<=t) two-tail	0.196		0.309		0.017		0.08		0.985		0.498	
t Critical two tail	2.093		2.093		2.093		2.093		2.093		2.093	

Figure 21. Typeface Score Distributions

Range	1S12	2S12	1S15	2S15	1S18	2S18	1D12	2D12	1D15	2D15	1D18	2D18
-1.2	0	0	0	0	0	0	0	0	0	0	0	0
-1.0	1	1	0	0	0	0	1	1	0	0	0	0
-0.8	0	0	0	0	0	0	0	0	0	0	0	0
-0.6	0	1	0	0	0	0	1	1	1	0	0	0
-0.4	3	1	3	0	0	1	0	0	2	1	0	0
-0.2	1	2	0	0	4	2	2	1	3	2	1	0
0.00	9	3	8	5	3	4	9	4	9	6	4	7
0.2	5	7	6	9	8	7	5	9	3	7	11	10
0.4	1	4	3	3	3	4	2	4	2	4	2	2
0.6	0	1	0	3	1	0	0	0	0	0	0	0
0.8	0	0	0	0	0	1	0	0	0	0	1	1
1.0	0	0	0	0	0	0	0	0	0	0	0	0
1.2	0	0	0	0	1	1	0	0	0	0	1	0

Figure 22. t-Test Distribution Analysis of Typeface 1 and Typeface 2 Tests

	t-Test: Two Sample Assume Equal Variances,		t-Test: Two Sample Assume Unequal Variances		t-Test: Paired Two Sample for Means	
	Type 1	Type 2	Type1	Type 2	Type 1	Type 2
Mean	-0.031	0.044	-0.031	0.044	-0.031	0.044
Variance	0.096	0.082	0.096	0.082	0.096	0.082
Observations	120	120	120	120	120	120
Pooled Variance	0.089		*		*	
Pearson Correlation	*		*		0.287	
Hypothesized Mean Diff.	0		0		0	
df	238		237		119	
t Stat	-1.952		-1.952		-2.310	
P(T<=t) one-tail	0.026		0.026		0.011	
t Critical one-tail	1.651		1.651		1.658	
P(T<=t) two-tail	0.052		0.052		0.023	
t Critical two-tail	1.970		1.970		1.980	

	1S12	1D12	2S12	2D12	1S15	1D15	2S15	2D15	1S18	1D18	2S18	2D18
Mean	-0.152	-0.091	-0.033	-0.021	-0.049	-0.125	0.140	0.010	0.109	0.122	0.107	0.062
Variance	0.079	0.097	0.137	0.105	0.051	0.078	0.047	0.041	0.114	0.106	0.127	0.033
Observations	20	20	20	20	20	20	20	20	20	20	20	20
Pearson Correlation	0.468		0.241		-0.330		0.283		0.635		-0.417	
Hypothesized Mean Diff.	0		0		0		0		0		0	
df	19		19		19		19		19		19	
t Stat	-0.880		-0.123		0.825		2.310		-.201		0.436	
P(T<=t) one-tail	0.195		0.452		0.210		0.016		0.418		0.334	
t Critical one-tail	1.729		1.729		1.729		1.729		1.729		1.729	
P(T<=t) two tail	0.390		0.903		0.420		0.032		0.836		0.668	
t Critical two tail	2.093		2.093		2.093		2.093		2.093		2.093	

Figure 23. Statistical Analysis of Layout, t-Test: Paired Two Sample for Means

	S12	D12	S158	D15	S18	D18
Mean	-0.092	-0.056	0.046	-0.057	0.108	0.092
Variance	0.0108	0.100	0.057	0.062	0.117	0.069
Observations	40.0	40	40	40	40	40
Pearson Correlation	0.347		0.41		0.232	
Hypothesized Mean Diff.	0.0		0		0	
df	30.0		39		39	
t Stat	-0.619		1.923		0.264	
P(T,=t) one-tail	0.270		0.031		0.396	
t Critical one-tail	1.685		1.685		1.685	
P(T<=t) two-tail	0.540		0.062		0.793	
T Critical two-tail	2.023		2.023		2.023	

Figure 24. Statistical Analysis of Layout, t-Test: Paired Two Sample for Means

Chapter 8

Conclusion

8.1 Conclusion

The diversity in the range of visual impairments highlights the complexity of making information more accessible to sight impaired readers. Owing to the variety of individual requirements, it is almost impossible for researchers to provide a definite set of rules that ensures optimum legibility. The aim of this research was to identify typographic factors that improves communication for the Retinitis Pigmentosa reader. An analysis of test results and interviews suggests that one cannot over-generalise, but rather establish the relative importance of these factors. Achieving optimum typographic legibility is influenced by an individual's specific eyesight deficiency and the extent of their disability. Unlike the significance attached to enlarging font sizes for many visual impairments, legibility is not necessarily increased for R.P sufferers with successive enlargement in type size. This is due to the extent of restriction enforced through loss of peripheral vision. Enlargement beyond the optimum type size for a readers field of perception is likely to obscure the amount of information observed, which inevitably results in decreased reading efficiency.

It was also noted from the test results that with the exception of one subject, whose RP condition was in an advanced stage, all RP subjects could read 12 point type, albeit some readers were unquestionably more comfortable with a larger type size. This finding suggests that type sizes close to normal body text are adequate for RP readers, and readability and will-power will have an important role in the amount of text a person with RP reads.

Testing subjects with 15 point type size resulted in consistent performance and on this basis it may be regarded as the most legible type size. There was significant variability in subject performance at 18 point. Although the relative impact of age on type size performance was not analysed, those who read better at 18 point may be indicative of an elderly population with a gradual loss of acuity or of a population that utilises glasses to correct visual inefficiency. In both populations larger type sizes compensate for the lack of focussing power in a field of vision. Furthermore, analysis of results suggests that age has no bearing on speed of reading. There was no significant difference in target word identification between the various age groups and subjects who read infrequently performed almost as well as avid readers.

The major problem for RP sighted readers is vision orientation within texts i.e. the maintaining or changing of eye position. There was no strong evidence from data analysis to suggest that either a one or two column grid improved legibility. However, from the researcher's observations during testing procedures, it was judged that the application of a two column grid presented a more functional layout for the vision deficiency associated with RP. It was further noted from subject observation that a two column grid decreased the amount of head movement needed for scanning and on the basis of regression analysis, the longer lines of a one column grid increased the number of regressions per sentence.

Optima, which is a stressed sanserif proved to be significantly more effective in terms of reading performance than Janson Text at 12 and 15 point type sizes. It was noted that at 18 point, the performance differential between Janson Text and Optima is nullified, which suggests that choice of typeface has no bearing on performance at large type sizes.

However, the physical design submission depicts the development of revised Optima *i.e.* the various adjustments made to certain letters and numerals to eliminate ambiguities by replacing them with forms that improve legibility. The revised typeface should not be judged aesthetically but as a functional typeface designed primarily to enhance legibility for RP readers. The changes made to the font were purely intended as an academic exercise.

Information was sought from the Patenting Office who advised that any changes made to the font without the permission of the designer were not in breach of copyright laws providing the font was not published. These revisions resulted from the findings of the literature review and from the statistical elements of this research. A lengthened hook on the lower case l, lower case t and the upper case was added to avoid confusion. Serifs were added to the upper case I and the numeral 1 was shortened, in context with the new style of non ranging numerals. Ascenders and descenders were lengthened proportionally to aid word shape recognition. Letters like p, b, b and d which are mirror images of each other often cause confusion. Ambiguities between these letters were eliminated by by changing the letters b and q. A heavy dot over the letters i and j was added to aid legibility. The comma was altered for a more distinctive punctuation mark and the full stop was enlarged. A cross stroke was added to the upper case G, to distinguish it from the upper case C. The stroke of the upper case letter Q was extended inside the bowl to avoid upper case Q and O being mistaken for one another. Numerals can often be misread since they tend to have a low degree of legibility. The revised numerals have been altered to hanging numerals which change their shape and size. This arrangement introduces ascender sand descenders which gives a distinctive appearance to each numeral. It was not viable to test the revised typeface due to time restraints and the subject's unwillingness to be re-tested.

A test involving the subjective preferences of the RP sample group to six colour combinations cards was administered in conjunction with the main testing process. Analysis of results showed that 50% of subjects preferred reading black text on a yellow background and the second preferred option was black text on a white background. White printed text on a black background was an unpopular choice for RP subjects, although computer users preferred this combination for screen reading.

The discrepancy between test results and questionnaires subsequentaly administered highlighted that subjective preferences are not an accurate indicator of legibility. There was little correlation between personal judgment of the most legible typeface and objective reading performance.

The objective of designers should be to provide information for the sight impaired in a way that conforms closely to general design principles. In reality the provision of information for specific sight impaired audiences may prove costly due to practical and economic considerations. This is especially true if the criteria are far removed from normal printing guidelines. Since no two sight impaired persons perceive in exactly the same way, it is unlikely that designers will develop a single set of legibility standards based on the needs of specific impairment groups. Researchers need to identify the broader limits of design for various deficiencies and to formulate generalised guidelines that meet most if not all of the needs of those impairments groups.

One of the main drawback s of this research was the shortage of experimental subjects constrained by the researchers resources. Certainly, for continuing research on this topic, a larger sample of subjects would be required to provide

conclusive statistics. The number of controls was also quite arbitrary due to the uncontrolled environment in which testing was carried out.

The relevance of contributions by the practicing designer is not always appreciated in theoretical research. To continue with such invaluable studies co-operation between designer and researcher is vital for an appreciation of the importance of combined practical design work and medical knowledge. And most importantly the opinion of the sight impaired reader must not be ignored as an active participant in research.

Appendix A

A1 Common Causes of Sight Impairments

A recent study in the United Kingdom suggests that one person in sixty have a registerable visual disability. [1] The list below outlines a number of common causes of sight impairments.

A2 Cataracts

Cataract is an opaqueness of the lens of the eye which prevents the passage of light required for good vision and fine detail. There are many possible causes of cataract, among them injury, general diseases or a disturbance to the nutrition of the lens most commonly a lack of vitamin C or calcium. The amount of vision affected by cataracts depends on the type of the cataract, its position in the lens and its size.

A3 Myopia

Myopia, or shortsightedness, is a term used to indicate 'short sight'. In the normal eye, rays of light coming from a distance should focus on the retina in the region of the macula. Myopia, however, is caused by an over lengthening of the eyeball beyond the normal growth period. The rays of light are focused in front of the retina and consequently the image appears blurred. In most cases of myopia, the lengthening of the eyeball is only moderate and correction may be possible with the aid of concave lenses. In more extreme cases the stretching of the retina can effect the efficiency of the macula and may result in tears, holes or rents in the retina.

1. This reference is from Bruce, I.W. 'Blind and Partially-Sighted Adults in Britain' in the R.N.I.B. survey.

A4 Macular Degeneration

Macular degeneration is caused by a defective blood supply which affects the fovea and macula, resulting in a noticeable reduction of vision for detail and for distance vision. Colour perception may also be affected. Macular degeneration, like RP, is progressive, which leads to a severe visual impairment.

A5 Albinism

This is an inherited condition associated with a lack of normal body pigment. The lack of pigment can happen over the whole of the body, or it can affect the eyes only. The condition is matched by a defective development in the eyes which is further responsible for an intolerance to light, a condition known as Photophobia. In albinism, the iris is almost transparent, resulting in an almost pinkish appearance. Albinism is associated with a visual impairment known as nystagmus, a rhythmic oscillation of the eyes. [2]

2. The above definitions of eye impairments are from a series of booklets published by The National Council for the Blind, 'About your Eyes' and from Mason, H., Spotlight on Special Educational Needs, A Nasen Publication.

Appendix B

Perceptibility of Peripheral Vision

It is necessary to have an understanding of the process of reading in order to explain the theory of 'perceptibility of peripheral vision'. When we read, our eyes move along the words of a sentence in a series of short, rapid jerks. During these saccadic eye movement, no clear vision is possible and perception only occurs during the fixation pauses which occur between the jerks and generally lasts about 1/4 of a second.

The field of peripheral vision varies from person to person, but generally the accuracy of recognition is about 12-15 letters on either side of the fixation point. Contrary to this, words with a clear word shape will be perceived accurately after the point of fixation and provide clues to the meaning of words before the next fixation point. A skilled reader can read a span of up to 30 letters (about 3 inches) during a single fixation point, actually needs to see less of each letter in order to identify it correctly. This is decreased dramatically for normal vision depending on the complexity of the material and the quality of print.

There is wide variation in eye movement patterns of poor readers, children and the visually impaired, who have a greatly reduced eye-span. As little as half an inch of text is visible to sight impaired readers during each fixation point and all sense of word pattern is lost. The image which is actually fixated upon will be focused on the fovea, the area of maximum acuity. The remainder will fall on the peripheral area of the retina.

At a normal reading distance, an average of only four letters will fall within the foveal area, and if type is enlarged to compensate for a sight impairment, the amount of visible letters will decrease depending on the type size. Reading efficiency will be decreased with enlargement as with each fixation there will be less information perceived and it will be necessary to increase eye movements to do the same amount of work. This principle is particularly noteworthy for readers in a degenerating stage of RP who focus all their attention on foveal word processing. [3]

Rayner and Bertea 1979, have observed that if peripheral viewing is restricted to less than 29 characters, saccade length is reduced between each fixation, thus affecting reading performance. [4]

3. Garzia, R. P., *Vision and Reading*, pp. 89, 135, 138.

4. Ehrlich D., 'A Comparative Study in the use of Closed Circuit Television Reading Machines and Optical Aids by Patients with Retinitis Pigmentosa and Maculopathy', p. 294.

Appendix C

The Significance of the Reliability of Measures

The significance of the reliability of measures used in reading and typographic research has been discussed by Hartley et al.

C2 Scanning depends on the nature of the material being scanned and the amount of text between the words being located. This method is particularly appropriate for testing the typographic layout of technical information and it appears to be a more sensitive measure than oral reading

C3 Measures of Comprehension vary in reliability depending on the difficulty of the method used and the relevance of the test questions. Rate of comprehension gives the correct measure of legibility for material that is intended to be read carefully. There are many ways of testing comprehension, including a cloze-test, whereby the reader is presented with missing words omitted in sentences at regular intervals throughout a paragraph or a text passage with a multiple choice questionnaire. The discrepancy with this method of testing is that the reader remembers most what he already knows. If a passage contains familiar material or ideas, it is read quickly and gives a high score for comprehension. In the same test, another paragraph may be unfamiliar and may require more concentration, thus giving a low score for comprehension.

C4 Silent Reading Speed Measures are difficult to assess because results rely partly on the integrity of the reader. This method affects the behaviour of the reader especially if they are aware that they will be tested on their

Appendix D

Tiresias Screenfont

Recent successful developments in typeface legibility for the sight impaired and elderly population, originated in a form of typeface called 'Tiresias Screenfont', designed by a group of professional designers and ophthalmologists. Initially this typeface was designed to surpass the previous screen font 'AlphaMosaic' used for subtitles and teletext on UK digital television. In the very early stages of the design process, all aspects including the legibility of AlphaMosaic were considered. The resulting typeface produced some of the following key attributes which enhance the legibility of the characters.

- A suitable font weight which was neither excessively bold or light.
- A large x-height with comfortable sized ascenders and descenders.
- Simple, well designed character shapes. The main design aim of the font was to avoid the problem of ambiguities between individual letters.
- Numerals which normally cause confusion were made as large as possible and emphasis was placed on distinguishing the numeral 1 from the numeral 7 and lowercase l.
- Inter character and word spacing was carefully controlled to avoid letters touching.
- Most importantly, kerning has been applied between character pairs. [6]

6. For reference visit the Tiresias Screenfont web site @, Http:// www.tiresias.org/font/design_report_sf.htm

A B C D E F G H I J K
L M N O P Q R S T U V
W X Y Z a b c d e f g
h i j k l m n o p q r
s t u v w x y z

1 2 3 4 5 6 7 8 9 0
! @ £ $ % ^ & * ( )
- = +

Figure 25. Tiresias Screenfont

Appendix E

Typeface Preferences from the Preliminary Test

E1 Bembo - Subjects found that Bembo appeared to be larger than the other typefaces which is ironic as all the typefaces had approximately the same x-height. As a typeface it was not too dark, quite attractive to the eye and had good overall spacing.

E2 Janson Text - There was a nice relationship between thick and thin strokes in comparison to other sanserif typefaces and the length of ascenders and descenders was very pleasing which gave the impression of an overall well spaced font. Subjects found that like Bembo, Janson Text appeared to be larger than the other fonts.

E3 Optima - Subjects reported that Optima appeared to have generous inbuilt leading which allows for clear visibility of the page. The vowels are very open and rounded and there is good symmetry to the font. The wide spacing made this font effortless to read.

E4 Arial - Arial is a rounded sanserif font with open counters. It was generally a popular typeface because subjects found it plain, sharp and more coherent, therefore less tiring on the eyes.

E5 Comparisons between Bembo and Janson Text

There are many apparent similarities between these two typefaces. Both fonts have large x-heights, tall ascenders and good average length descenders. Janson Text is a larger and blacker font than Bembo which is more condensed. The capitals of both fonts have similar qualities as have the numeral although they are slightly more elongated in Janson Text.

E6 Comparisons between Optima and Arial

Optima and Arial have less similarities than Bembo and Janson Text. Arial has the appearance of a blocky, quite simplified typeface and it runs much wider than Optima. Optima, although a sanserif, with it's varying thickness in strokes has an appearance more common to a serif face whereas Arial has a relative evenness to each character.

Appendix F

Typeface Library

Arial

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Baskerville

abcdefghijklmnopwqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Bembo

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Cantoria

abcdefghijklmnopqrstuvwwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Eras

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Formata

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Gill Sans

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Ionic

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Janson Text

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Optima

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Palatino

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Rockwell

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Sabon

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Stempel Schneidler

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789

Appendix G

On-line Interviews with RP Subjects

A series of personal interviews were held with RP readers. Below are two transcripts from interviews that were conducted over the internet with RP sighted readers.

- 'I access the internet through web-tv, not a computer. I have a 32 inch tv and since the print is larger than a computer monitor it would make sense that it would be easy to read but it is one of the most troublesome! The background is black with green print and after reading for a short time I develop double vision, primarily in my lower left field. Website graphics drive me crazy - I think they are often confusing even for normal sighted people. Glossy magazines with very high contrast, shiny black/white large type seems to 'jump out' at me and is difficult to read. And oddly enough, newspaper print (well not the classifieds) is usually comfortable to read.' [19]

19. RP list - lucianne@webtv.net

• 'All I can say about the matter is that the greater the contrast between type and background, the better. That is for me at least, considerably more important than the size of the type. Also since one of the typical difficulties in RP is tunnel vision, it is much easier to read relatively narrow columns of print. Wide columns, long lines, are very difficult and exhausting.'

'Generally as I mentioned earlier the greater the contrast between type-face and background, the easier it is to read: also the less tiring. RP eyes can tire very easily. And yes, the tunnel vision that is common to almost everybody with RP means that the long horizontal lines are very difficult.'

'I used to be an avid newspaper reader but I have reluctantly given that up because it is such hard and confusing work. The actual columns of print are not bad, because they are usually not too long, but the headlines are too large, irregular and confusing. I have to hold a newspaper far away in order to read the headlines; and up close in order to read the news columns.'

'So the other important factor, aside from good contrast, is regularity of type size. Irregular sizes makes the things that you mentioned, bills, tv guides, catalogues, etc, sometimes very difficult to read. 'I once had normal vision, so I know that an artistic mixture of fonts is pleasing aesthetically to people with good eyes, but for us the mixture just adds to confusion. That is why reading a book, with its regular unvarying type, is easier than reading most other things. Simplicity of visual information is important.' [20]

20. William Thornton-Trump - trump@istar.com

Appendix H

Subject Responses from Interviewing

A considerable amount of research has been undertaken into sight impairments but surprisingly there is little relevance given to the opinions of sight impaired readers themselves. Subject's opinions are very relevant in testing procedures because they are the only people who can possibly know the limitations of their vision. The following factors are not scientific data but they underline some of the difficulties of reading with RP. They include a variety of comments from the personal responses of subjects as a result of a questionnaire at the end of the testing process.

- Loss of place when reading causes an increase in the amount of regressions. Subjects often skipped words and a considerable amount of time was wasted if subjects lost their place. [21]

- Reading may be very slow, depending on the particular stage and condition of the impairment, and the reader may need the use of a finger to keep place.

- Small type and overly large type can equally cause a problem for readers. A typical example is the difficulty readers experience, when trying to read bad quality newspaper ink.

21. The amount of errors made by RP subjects was excessive in comparison to 'normal' sighted readers.

- Legibility decreases when letters are too similar. Readers experienced confusion with certain letters of the alphabet e.g. cl for d, m for n, i for l or 1.

- There may be confusion distinguishing unfamiliar words that have two consecutive similar letters; this is particularly true of two ls merging.

- Readers experience difficulty trying to discriminate tight, badly spaced lettering which subsequently causes focusing problems and blurring of the counterforms of letters which tend to fill in.

- Different variations in letterforms cause confusion especially for the younger RP reader and non-frequent readers, i.e. the two tiered a and double looped g. [22]

- Good contrast between typeface and background is a necessity. Equally if colours have too similar a hue, they can be difficult to decipher. Navy and black in particular appear very similar and they are often mistaken in clothing.

- Text printed over an illustrated background or a photograph causes frustration and confusion and should be avoided.

22. Research has proved that the italic version of a typeface is generally confusing and unacceptable and slows down the rate of reading for the sight impaired reader.

- Optimum illumination is a fundamental issue for the reading environment. It is essential to avoid glare from all possible sources. Adjusting to dazzling and glaring lights can cause temporary blindness. This includes direct sunlight which reflects off glossy paper such as in magazines and other highly reflective surfaces. The dim lighting on a dull day is the best light for reading and mobility.

- Signage often causes a problem especially when aesthetics overrule practicality. Signs should be universally representative and designed using clear, legible fonts or imagery. Confusing signs should be replaced with less ambiguous signs.

- Labelling and instructions on packaging and containers can cause significant problems especially when printed in a very small point size.

- Badly designed household bills and bank statements are difficult to decipher, as are the faint print outs from ATM's. The lack of adequate spacing for details to be completed on forms is often overlooked.

- The similarities between coins i.e. the size of the 2 pence and 20 pence piece makes distinguishing between the two coins difficult.

- RP sighted individuals often experience difficulty discerning the difference between the colours black and navy.

- Subjects who read frequently mentioned their inability to see new paragraphs that begin at the bottom of a page in a book.

- Erdmann and Dodge 1898, found that long words, particularly those of characteristic form, were more readily recognised than short ones. A number of subjects made similar comments when searching for the target words that confirms this theory. [23]

- One RP reader commented on the discomfort of reading type at an angle. Spencer in his book, claims that 'reading efficiency is severely reduced by any departure from the horizontal and by departure from the 90 degree angle in reading.' [24]

23. Spencer, *The Visible Word*, p. 17.

24. Spencer, op. cit., p. 55.
This has particular implications for sight impaired readers who may need to use large print books. The size and weight of a book may influence the distance and angle at which it is read e.g. large print books may be left on a flat surface in front of the reader rather than being held in the hand. This implies that the readers line of vision is at an angle to the page of text more so than if the book was hand held.

Appendix I

Test Instructions

The written instructions were as follows;

I am giving you a piece of text to read. In the left hand margin of each text, there is a list of words. The words occur in the text in the order in which they are listed in the margin. You are required to underline each word in turn as it appears in the text. It is necessary that you look for the words in the order that they are listed and that you do not omit any of the words before the previous word has been found. A horizontal rule indicates the division in the text where the target words can be found.

In the passage where there are two columns of text, the first group of target words can be found in the first column and the second group of target words correspond with the second column. Please do not skip any of the words. You may tilt the page to whatever angle you are comfortable reading at and to avoid any glare. Read the text at a quick pace.

You are requested to read at a distance that is most comfortable to your normal reading position and to maintain this distance for the duration of the testing. When I say 'start', begin to work immediately. You will have one minute to complete each passage and then I will say 'stop'. Please stop immediately even though you may be just ready to underline a word. We will then move on to the next passage which complies with the same instructions. If you have any questions, please ask me now.

Appendix J

S	SEX	AGE	R.P. DIAGNOSIS	READING INTEREST	READING DISTANCE	SIZE	TYPEFACE	COLUMN
S1	Male	46-60	Recessive	Frequent	Less than 8 in.	18pt	Optima	One
S2	Male	Below 18	---	Rarely	Less than 8 in.	18pt	Optima	One
S3	Male	Below 18	---	N. & M. only	More than 8in.	18pt	Janson Text	Two
S4	Male	46-60	Dominant	Average	More than 8in.	15pt	Optima	One
S5	Female	Over 60	Recessive	Frequent	More than 8in.	15pt	Optima	Two
S6	Female	Over60	Recessive	Frequent	More than 8in.	18pt	Janson Text	One
S7	Male	46-60	Dominant	N. & M. only	More than 8in.	15pt	Optima	Two
S8	Female	46-60	Dominant	Rarely	More than 8in.	18pt	---	Two
S9	Male	18-30	Recessive	Frequent	More than 8in.	12pt	Optima	Two
S10	Female	Over 60	Dominant	Frequent	More than 8in.	15pt	Optima	One
S11	Female	31-45	Recessive	Frequent	Less than 8in.	12pt	Optima	One
S12	Female	31-45	Recessive	Frequent	More than 8in.	15pt	Janson Text	Two
S13	Male	31-45	Sporadic	Frequent	More than 8in.	15pt	Janson Text	One
S14	Female	18-30	Ushers Syndrome	Frequent	More than 8in.	12pt	Janson Text	Two
S15	Female	46-60	Recessive	Average	More than 8in.	18pt	Janson Text	Two
S16	Female	18-30	Ushers Syndrome	Frequent	More than 8in.	12pt	Janson Text	One
S17	Female	46-60	Dominant	Rarely	Less than 8in.	12pt	Janson Text	Two
S18	Female	31-45	Ushers Syndrome	Frequent	More than 8in	18pt	Optima	Two
S19	Male	31-45	X-linked	N. & M. only	More than 8in	15pt	Janson Text	One
S20	Male	31-45	X-linked	N. & M. only	More than 8in	15pt	Janson Text	Two

N. & M. only - Newspapers and Magazines only

Figure 26. Information chart on R.P. Subjects

Appendix K

Scores and Details from Individual Subjects

*Refers to when a subject skipped target words in a test passage.

Subject 1

Tests	Scores
1.1	6
1.2	11
1.3	13
1.4	12
1.5	7*
1.6	11
2.1	13
2.2	12*
2.3	11*
2.4	10
2.5	11
2.6	10

Details

Sex; Male
Age Bracket; 46-60
Use of Optical Aids; No optical aids
Type of R.P; Recessive
Reading Distance; Less than 8 in.
Reading Interest; Frequent
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 18pt
Preferred Typeface; Optima
Grid Preference; One Column

Subject 2

Tests	Scores
1.1	----
I.2	1
1.3	2
1.4	----
1.5	1
1.6	2
2.1	----
2.2	1
2.3	2
2.4	----
2.5	1
2.6	1

Details

Sex; Male
Age Bracket; Below 18
Use of Optical Aids; No optical aids
Type of R.P; ----
Reading Interest; Rarely
Reading Distance; Less than 8 in.
Preferred Colour Combination; Black on White
Preferred Type Size; 18pt
Preferred Typeface; Optima
Grid Preference; One column

Subject 3

Tests	Scores
1.1	16
1.2	19
1.3	21
1.4	18
1.5	14
1.6	19
2.1	10
2.2	13
2.3	16
2.4	15
2.5	12
2.6	16

Details

Sex; Male
Age Bracket; Below 18
Use of Optical Aids; No optical aids
Type of R.P; ----
Reading Distance; More than 8in.
Reading Interest; Newspapers and magazines only
Preferred Colour Combination; Black on white
Preferred Type Size; 18pt
Preferred Typeface; Janson Text
Grid Preference; Two column

Subject 4

Test	Scores
1.1	12
1.2	15*
1.3	13*
1.4	10*
1.5	5
1.6	11
2.1	17
2.2	10
2.3	13
2.4	8
2.5	10
2.6	12

Details

Sex; Male
Age Bracket; 46-60
Use of Optical Aids; Spectacles for Reading only
Type of R.P; Dominant
Reading Interest; Average
Reading Distance; 8 in. or more
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; One column

Subject 5

Tests	Scores
1.1	9*
I.2	9
1.3	13
1.4	6
1.5	9*
1.6	13
2.1	14
2.2	15
2.3	12
2.4	10
2.5	13
2.6	12

Details

Sex; Female
Age Bracket; Over 60
Use of Optical Aids; No
Type of R.P; Recessive
Reading distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; Two Column

Subject 6

Test	Scores
1.1	5
1.2	5
1.3	13
1.4	9
1.5	6
1.6	10
2.1	11
2.2	10
2.3	12
2.4	12
2.5	12
2.6	12

Details

Sex; Female
Age Bracket; Over 60
Use of Optical Aids; Spectacles for reading only
Type of R.P; Recessive
Reading Interest; Frequent
Reading Distance; 8in. or more
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 18pt
Preferred Typeface; Janson Text
Grid Preference; One column

Subject 7

Test	Scores
1.1	11
1.2	12
1.3	7
1.4	12
1.5	2
1.6	10
2.1	9
2.2	14
2.3	12
2.4	10
2.5	8
2.6	10

Details

Sex; Male
Age Bracket; 46-60
Use of Optical Aids; Spectacles all the time
Type of R.P; Dominant
Reading Interest; Newspapers and Magazines only
Reading Distance; 8in. or more
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; Two column

Subject 8

Test	Scores
1.1	8
I.2	9
1.3	10*
1.4	11*
1.5	10
1.6	12
2.1	6*
2.2	15
2.3	8
2.4	11*
2.5	8*
2.6	12

Details

Sex; Female
Age Bracket; 46-60
Use of Optical Aids; Spectacles for reading only & Magnifier
Type of R.P; Dominant
Reading Interest; Rarely
Reading Distance; 8in or more
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 18pt
Preferred Typeface; No preference
Grid Preference; Two column

Subject 9

Test	Scores
1.1	15
1.2	17
1.3	17
1.4	17
1.5	17
1.6	19
2.1	19
2.2	20
2.3	17
2.4	13
2.5	18
2.6	17

Details

Sex; Male
Age Bracket; 18-30
Use of Optical Aids; Spectacles all the time
Type of R.P; Recessive
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Yellow on Blue
Preferred Type Size; 12pt
Preferred Typeface; Optima
Grid Preference; Two Column Grid

Subject 10

Test	Scores
1.1	16
I.2	12
1.3	17
1.4	9
1.5	11
1.6	13
2.1	12
2.2	20
2.3	18
2.4	14
2.5	16
2.6	16

Details

Sex; Female
Age Bracket; Over 60
Use of Optical Aids; Spectacles for reading only
Type of R.P; Dominant
Reading Distance; 8in or more
Reading Interest; Frequent
Preferred Colour Combination; White on Black
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; One column

Subject 11

Tests	Scores
1.1	3
1.2	2
1.3	4
1.4	3
1.5	4
1.6	6
2.1	5
2.2	3
2.3	6
2.4	1
2.5	3
2.6	3

Details

Sex; Female
Age Bracket; 31-45
Use of Optical Aids; Magnifier
Type of R.P; Recessive
Reading Distance; Less than 8in.
Reading Interest; Frequent
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 12pt
Preferred Typeface; Optima
Grid Preference; One Column

Subject 12

Test	Scores
1.1	6*
1.2	4
1.3	6
1.4	7
1.5	7
1.6	9
2.1	5
2.2	9*
2.3	10
2.4	8
2.5	10
2.6	7

Details

Sex; Female
Age Bracket; 31-45
Use of Optical Aids; Spectacles all the time
Type of R.P; Recessive
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Janson Text
Grid Preference; Two column

Subject 13

Test	Scores
1.1	15
1.2	17
1.3	18
1.4	14
1.5	9
1.6	16
2.1	18
2.2	18
2.3	15
2.4	18
2.5	9
2.6	14

Details

Sex; Male
Age Bracket; 31-45
Use of Optical Aids; No optical aids
Type of R.P; Sporadic
Reading Distance; More than 8in.
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Janson Text
Grid Preference; One column

Subject 14

Test	Scores
1.1	15
1.2	14
1.3	19
1.4	16
1.5	13
1.6	20
2.1	17
2.2	20
2.3	18
2.4	18
2.5	19
2.6	19

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; Contact lenses
Type of R.P; Recessive
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 12pt
Preferred Typeface; Janson Text
Grid Preference; Two column

Subject 15

Tests	Scores
1.1	15
I.2	17
1.3	17
1.4	16*
1.5	16
1.6	17
2.1	17
2.2	16
2.3	19
2.4	15
2.5	17
2.6	17

Details

Sex; Female
Age Bracket; 46-60
Use of Optical Aids; Spectacles all the time
Type of R.P; Recessive
Reading Distance; 8in. or more
Reading Interest; Average
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 18pt
Preferred Typeface; Janson Text
Grid Preference; Two column

Subject 16

Tests	Scores
1.1	18
1.2	14
1.3	11
1.4	15
1.5	16
1.6	20
2.1	18
2.2	17
2.3	18
2.4	19
2.5	16
2.6	19

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; Spectacles all the time
Type of R.P; Recessive (Ushers Syndrome)
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Yellow on Black
Preferred Type Size; 12pt
Preferred Typeface; Janson Text
Grid Preference; One column

Subject 17

Tests	Scores
1.1	11
I.2	19
1.3	9
1.4	13
1.5	16
1.6	11
2.1	13
2.2	15
2.3	11
2.4	15
2.5	12
2.6	10

Details

Sex; Female

Age Bracket; 46-60

Use of Optical Aids; Spectacles all the time

Type of R.P. Dominant

Reading Distance; Less than 8in.

Reading Interest; Rarely

Preferred Colour Combination; White on Black

Preferred Type Size; 12pt

Preferred Typeface; Janson Text

Grid Preference; Two Column

Subject 18

Tests	Scores
1.1	8
I.2	18
1.3	18
1.4	18
1.5	11
1.6	13
2.1	20
2.2	19
2.3	13
2.4	17
2.5	18
2.6	17

Details

Sex; Female
Age Bracket; 31-45
Use of Optical Aids; Contact lenses
Type of R.P; Sporadic R.P. & Ushers Syndrome
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on Yellow
Preferred Type Size; 18pt
Preferred Typeface; Optima
Grid Preference; Two Column

Subject 19

Tests	Scores
1.1	17
1.2	17
1.3	13
1.4	13
1.5	18
1.6	11
2.1	19
2.2	21
2.3	22
2.4	24
2.5	23
2.6	15

Details

Sex; Male
Age Bracket; 31-45
Use of Optical Aids; No Optical aids
Type of R.P; X-linked
Reading Distance; 8in. or more
Reading Interest; Newspapers/Magazines only
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Janson Text
Grid Preference; One Column

Subject 20

Tests	Scores
1.1	4
1.2	4
1.3	4
1.4	5
1.5	5
1.6	3
2.1	1
2.2	3
2.3	2
2.4	4
2.5	3
2.6	6

Details

Sex; Male
Age Bracket; 31-45
Use of Optical Aids; Spectacles all the time
Type of R.P; X-linked
Reading Distance; 8in. or more
Reading Interest; Newspapers/Magazines only
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Janson Text
Grid Preference; Two Column

Control Group Subject A

Tests	Scores
1.1	16*
1.2	19
1.3	15
1.4	14
1.5	10
1.6	15
2.1	19
2.2	19
2.3	21
2.4	14*
2.5	19
2.6	12*

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; No optical aids
Reading Distance; 8in. or more
Reading Interest; Newspapers/Magazines only
Preferred Colour Combination; Blue on Yellow
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; One Column

Control Group Subject B

Tests	Scores
1.1	23*
1.2	21
1.3	23*
1.4	22
1.5	13
1.6	22
2.1	23
2.2	22
2.3	22
2.4	19
2.5	21
2.6	21*

Details

Sex; Male
Age Bracket; 18-30
Use of Optical Aids; No optical aids
Reading Distance; 8in. or more
Reading Interest; Newspapers/Magazines only
Preferred Colour Combination; Black on White
Preferred Type Size; 12pt
Preferred Typeface; Optima
Grid Preference; One Column

Control Group Subject C

Tests	Scores
1.1	24
I.2	24
1.3	24
1.4	24
1.5	24
1.6	24
2.1	24
2.2	24
2.3	24
2.4	24
2.5	24
2.6	24

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; No optical aids
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 12pt
Preferred Typeface; Janson Text
Grid Preference; One Column

Control Group Subject D

Tests	Scores
1.1	24
1.2	24
1.3	24
1.4	24
1.5	24*
1.6	22
2.1	24
2.2	22*
2.3	22
2.4	23*
2.5	24
2.6	24

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; Spectacles all the time
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Janson Text
Grid Preference; One Column

Control Group Subject E

Tests	Scores
1.1	24
I.2	24
1.3	24
1.4	24
1.5	24
1.6	24
2.1	24
2.2	24
2.3	24
2.4	22*
2.5	24
2.6	24

Details

Sex; Female
Age Bracket; 18-30
Use of Optical Aids; Spectacles all the time
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; One Column

Control Group Subject F

Tests	Scores
1.1	12
1.2	20
1.3	24
1.4	14
1.5	18
1.6	23*
2.1	22
2.2	23*
2.3	24
2.4	24
2.5	23*
2.6	23*

Details

Sex; Male
Age Bracket; 31-45
Use of Optical Aids; Spectacles for reading only
Reading Distance; 8in. or more
Reading Interest; Frequent
Preferred Colour Combination; Black on White
Preferred Type Size; 15pt
Preferred Typeface; Optima
Grid Preference; Two Column

Control Group Subject G

Tests	Scores
1.1	23*
I.2	23*
1.3	22*
1.4	24
1.5	22*
1.6	24
2.1	24
2.2	23*
2.3	23*
2.4	23*
2.5	24
2.6	24

Detailx

Sex; Female

Age Bracket; 18-30

Use of Optical Aids; No optical aids

Reading Distance; 8in. or more

Reading Interest; Average

Preferred Colour Combination; Black on White

Preferred Type Size; 12pt

Preferred Typeface; Janson Text

Grid Preference; One Column

Results after 20 interviews with RP Readers

Male / Female ratio;	9:11
Age Bracket;	Below 18; 2 18-30; 3 31-45 ;6 46-60; 6 Over 60; 3
Type of RP;	Dominant; 5 Recessive; 9 X-Linked; 2 Don't know; 2 Sporadic; 2
Use of Optical Aids;	Spectacles all the time; 9 Spectacles for reading only; 4 Magnifier; 1 No optical aids; 6
Reading Distance;	Less than 8 inches; 4 More than 8 inches; 16
Reading Interest;	Frequent; 11 Average; 2 Newspapers and magazines only; 4 Rarely; 3
Preferred Colour Combination;	Black on White; 7 White on Black; 2 Black on Yellow; 10 Yellow on Black; 1 Yellow on Blue; --- Blue on Yellow; ---
Preferred Type Size;	12pt; 5 15pt; 8 18pt; 7
Preferred Typeface;	Optima; 9 Janson Text; 10 No Preference; 1
Grid preference;	One Column; 8 Two Column; 12

Results after 7 interviews with normal sighted readers

Male / Female ratio;	2:5
Age Bracket;	Below 18; --- 18-30; 6 31-45; 1 46-60; --- Over 60; ---
Use of Optical Aids;	Spectacles all the time; 2 Spectacles for reading only; 1 No Optical aids; 4
Reading Distance;	Less than 8 inches; --- More than 8 inches; 7
Reading Interest;	Frequent; 4 Average; 1 Newspapers and magazines only; 2
Preferred Colour Combination;	Black on White; 6 White on Black; --- Black on Yellow; --- Yellow on Black; --- Yellow on Blue; --- Blue on Yellow; 1
Preferred Type Size;	12pt; 3 15pt; 4 18pt; ---
Preferred Typeface;	Optima; 4 Janson Text; 3
Grid preference;	One Column; 6 Two Column; 1

Appendix L

internal
progress
decline
areas
foodstuffs
related
stems
bio-cultural
plant
machinery
meagre
inadequate

The agricultural sector is the most important single economic activity within the internal structure of the Latin American economy. It is also the slowest in terms of economic progress in the postwar period. A real decrease in per capita farm output has occurred in the last two decades, there has been a decline in the standard of living in rural areas, and most of the countries have been forced to import food stuffs which they might well produce within their own territories. Most of the difficulties of agriculture are related to the under-utilisation of land, which stems from inadequate methods of cultivation and from the peculiar pattern of landholding.

Factors including poor employment of bio-cultural techniques such as plant genetics, slight use of fertilisers, practically no employment of machinery, and insufficient irrigation projects result in low productivity, smaller surpluses to be marketed and meagre returns. Inadequate methods of cultivation are intrinsically related to landholding systems, namely the "Latifundia". Peasants in the "haciendas". or large estates, are usually not paid wages for their production but instead they are given food rations and granted small plots of land. They do not, therefore, constitute a market for any manufactured goods which may be produced by their countries' industries. The landowner does not contribute substantially to the economy either, since taxes are relatively low and do not form a deterrent against spending on foreign goods or investments abroad. The counterpart of the latifundium is the "minifundia". The minifundia lack not only land but also other inputs necessary to raise productivity. The small scale farmers are at the margin of the market economy and represent neither a producing force for food commodities nor an effective demand for industrial products. A third form of land ownership is the Indian community which forms a self-sustained unit with little production, if any, to be sold in the nearest town.

estates
rations
produced
landowner
taxes
investments
inputs
margin
commodities
industrial
community
sold

Figure 27. Test Material Janson Text, 1 Column, 12 pt on 15pt

economic
slowest
decrease
rural
forced
difficulties
cultivation
employment
genetics
practically
surpluses
cultivation

The agricultural sector is the most important single economic activity within the internal structure of the Latin American economy. It is also the slowest in terms of economic progress in the postwar period. A real decrease in per capita farm output has occurred in the last two decades, there has been a decline in the standard of living in rural areas, and most of the countries have been forced to import food stuffs which they might well produce within their own territories. Most of the difficulties of agriculture are related to the under-utilisation of land, which stems from inadequate methods of cultivation and from the peculiar pattern of landholding.

Factors including poor employment of bio-cultural techniques such as plant genetics, slight use of fertilisers, practically no employment of machinery, and insufficient irrigation projects result in low productivity, smaller surpluses to be marketed and meagre returns. Inadequate methods of cultivation are intrinsically related to landholding systems, namely the "Latifundia". Peasants in the "haciendas", or large estates, are usually not paid wages for their production but instead they are given food rations and granted small plots of land. They do not, therefore, constitute a market for any manufactured goods which may be produced by their countries' industries. The landowner does not contribute substantially to the economy either, since taxes are relatively low and do not form a deterrent against spending on foreign goods or investments abroad. The counterpart of the latifundium is the "minifundia". The minifundia lack not only land but also other inputs necessary to raise productivity. The small scale farmers are at the margin of the market economy and represent neither a producing force for food commodities nor an effective demand for industrial products. A third form of land ownership is the Indian community which forms a self-sustained unit with little production, if any, to be sold in the nearest town.

landholding
wages
plots
countries'
substantially
deterrent
latifundium
market
effective
products
unit
nearest

Figure 28. Test Material Optima, 1 Column, 12 pt on 15pt

Appendix M

Name:

Sex:
Male
Female

Age Bracket:
Below 18
18-30
31-45
46-60
Over 60

Use of Optical Aids:
Spectacles all the time
Spectacles for reading only
Magnifier
No optical Aids

Which type of RP do you suffer from?
Dominant
Recessive
X-linked
Ushers Syndrome
Sporadic

Reading Distance
Less than 8in.
More than 8in.

Reading Interest
Frequent
Average
Newspaper/Magazines only
Rarely

Which type size did you prefer?
12pt
15pt
18pt

Which typeface did you prefer?
Janson Text
Optima

Which layout did you prefer?
1 Column
2 Column

Which colour combination provided optimum clarity?

What kind of problems do you confront when reading?

Does general information for the public cater for people with RP?

Figure 29. Testing Sheet Questions

Appendix N

Testing Plots

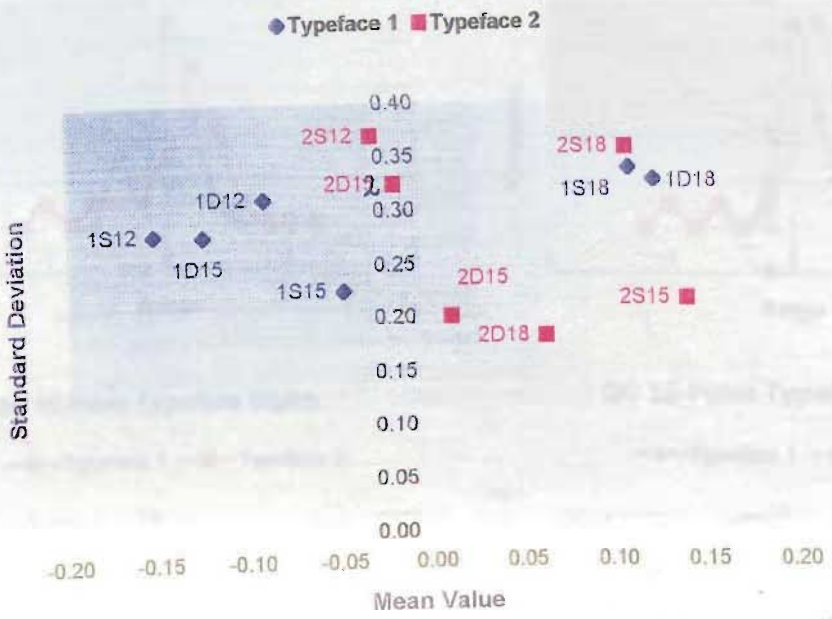

Figure 30. Mean & Standard Deviation By Test

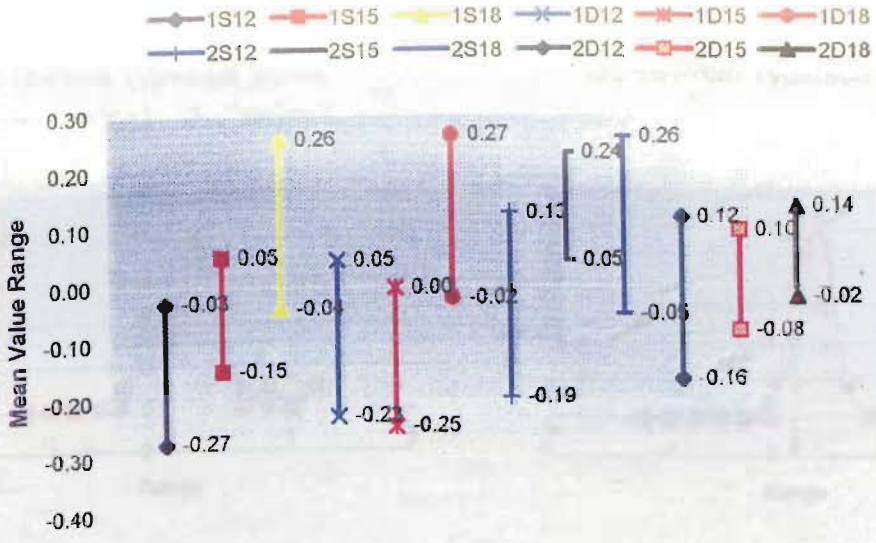

Figure 31. Mean Value Ranges By Test

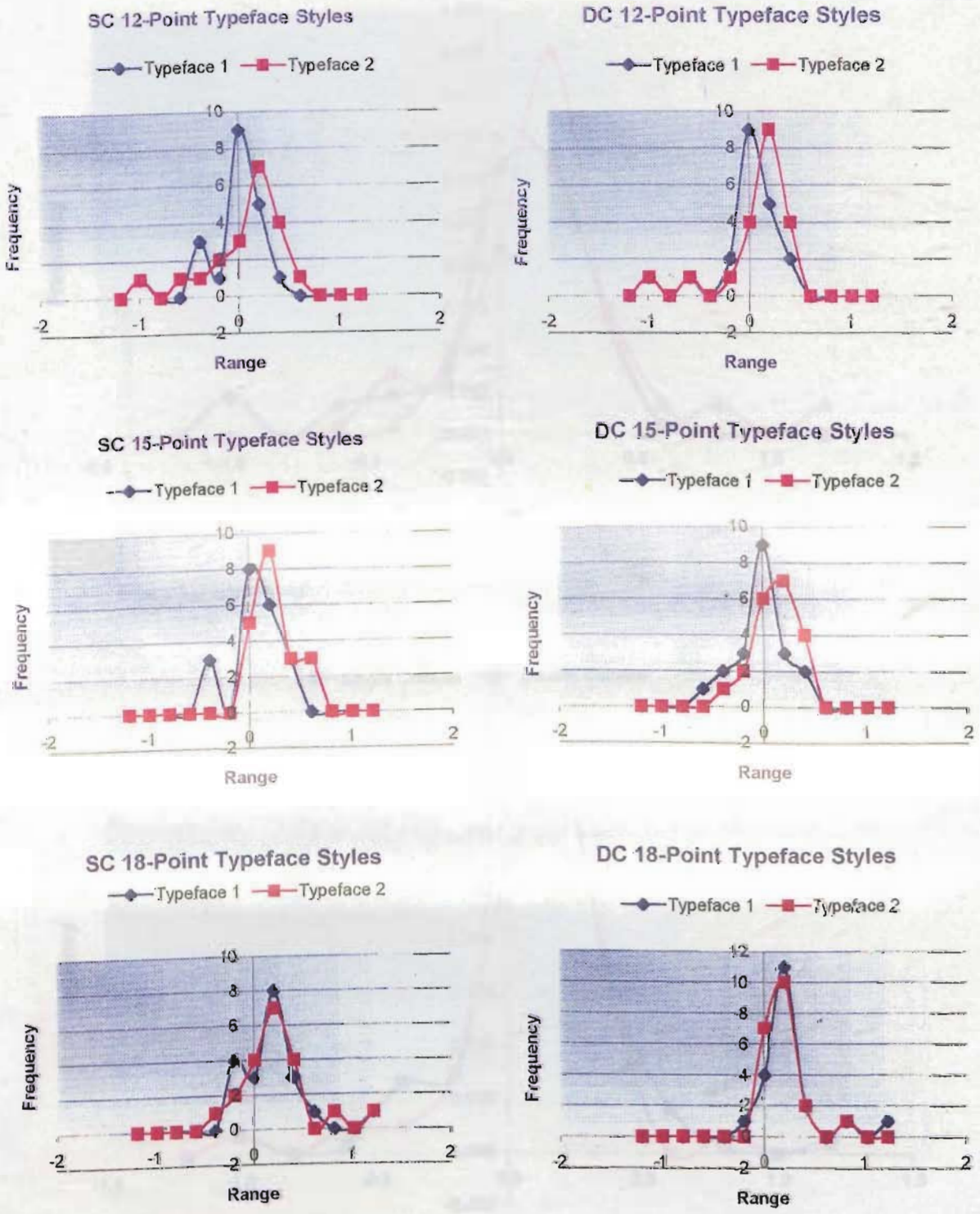

Figure 32. Test Result Distributions

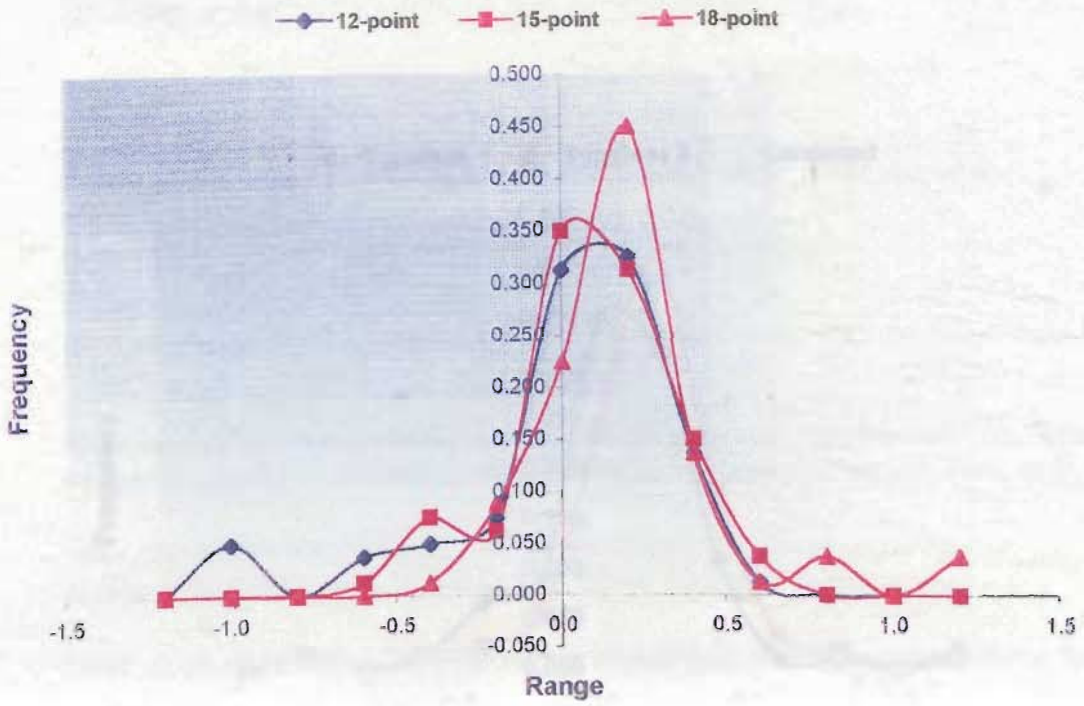

Figure 33. Normalized Frequency Distributions by Size

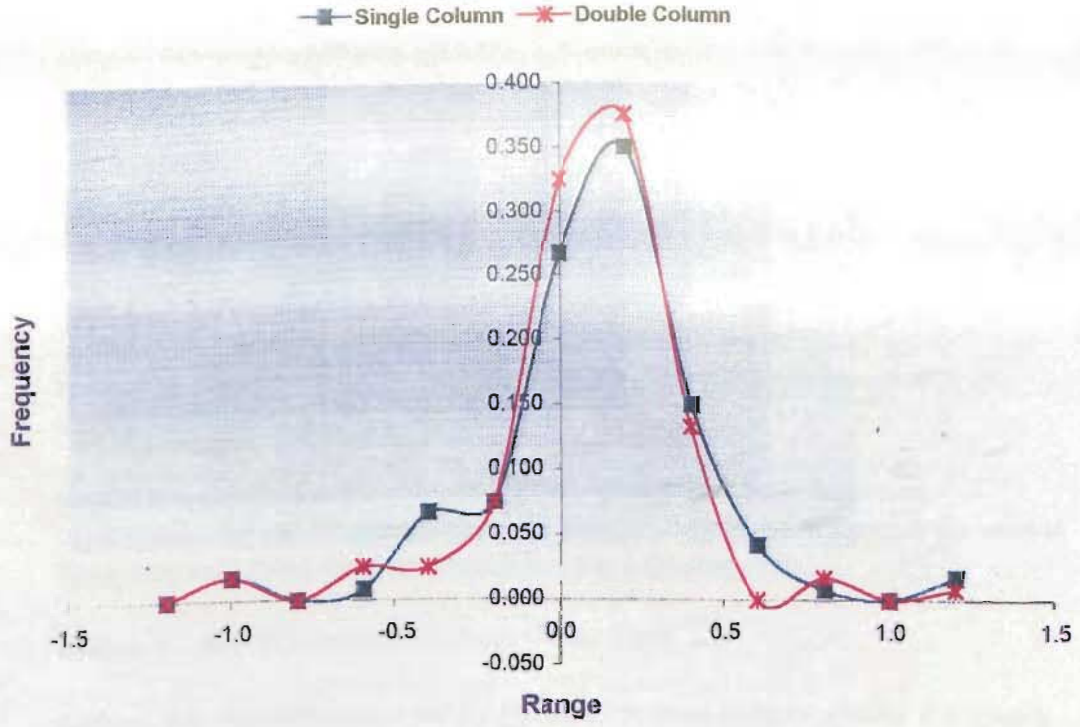

Figure 34. Normalized Frequency Distributions by Layout

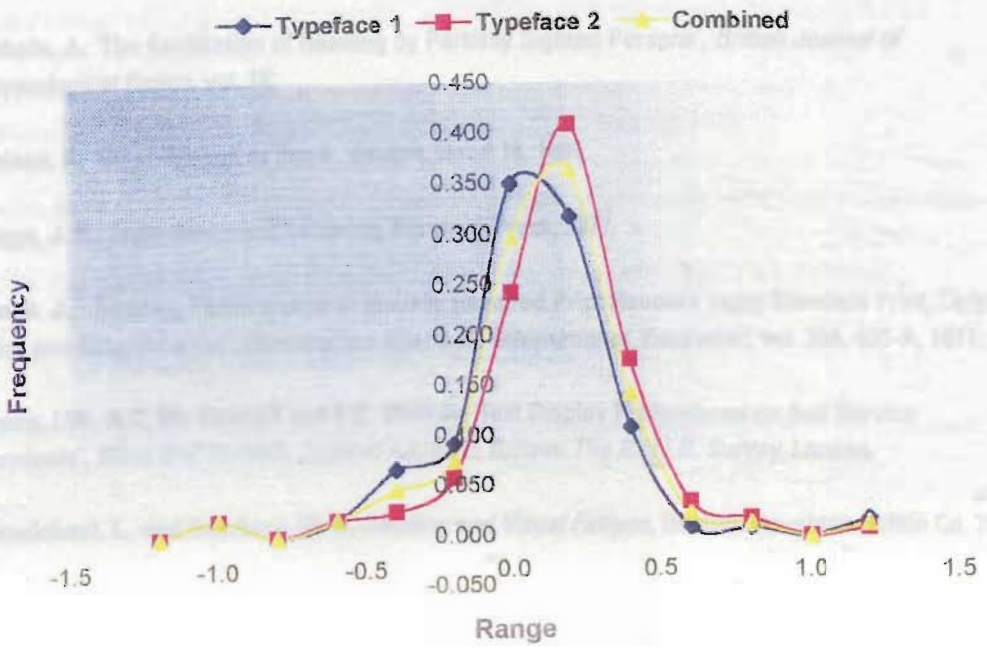

Figure 35. Normalized Frequency Distributions by Typeface

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